ARMY UNMANNED AERIAL VEHICLE (UAV) REQUIREMENTS
AND THE JOINT UAV PROGRAM

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE

by

WILLIAM R. HARSHMAN, MAJ, USA
B.S.E.E., Indiana Institute of Technology, 1975

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At the direction of Congress, all non-lethal unmanned aerial vehicle (UAV) programs of the military services were consolidated into a joint Department of Defense program. A result of this legislation was the publication of a joint master plan directing the future of UAV development. The purpose of this study is to determine if the Department of Defense joint unmanned aerial vehicle program will satisfy the UAV needs of the Army to conduct tactical intelligence collection. The study compares the requirements of the Army UAV program against the specifications for the joint close-range (JUAV-CR) and joint short-range (JUAV-SR) UAV systems. The study concludes the Army has clearly defined its requirements for unmanned aerial vehicle operations. The research finds significant differences exist between the Army and joint programs. However, these differences do not impact on the essential needs of the Army. The joint UAV program supports the UAV needs of the Army. After a slow start, the joint UAV program is proceeding rapidly. Barring funding constraints, the Army, and the other services, will soon possess an operational short-range (out to 150 km) UAV system capable of performing tactical intelligence collection.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

ARMY UNMANNED AERIAL VEHICLE (UAV) REQUIREMENTS AND THE JOINT UAV PROGRAM: An analysis of how the joint UAV program satisfies the Army's requirements for intelligence collection UAVs, by Major William R. Harshman, USA, 122 pages.

After many years of attempting to develop and field operational unmanned aerial vehicles (UAV), the UAV programs of the military services were halted at the direction of Congress. All non-lethal UAV programs were consolidated into a joint Department of Defense program. A result of this legislation was the publication of a joint master plan directing the future of UAV development. The purpose of this study is to determine if the Department of Defense joint unmanned aerial vehicle program will satisfy the UAV needs of the Army to conduct tactical intelligence collection.

This study employs a simple methodology. First, UAV requirements as defined by both the Army and the Department of Defense are identified. Second, the Army requirements are tested for validity within the framework of the Army's capstone war-fighting doctrine, AirLand Battle, and supporting doctrine for the conduct of intelligence operations. Third, the operational characteristics specified by the Army are compared with the same criteria as defined for the equivalent joint UAV system. The final step is the identification of differences in the two programs and determining the impact on future Army UAV operations.

The study concludes, the Army has clearly defined its requirements for unmanned aerial vehicle operations. These requirements are valid and fully support the Army's war-fighting doctrine. The research finds significant differences exist between the Army and joint programs. However, these differences do not impact on the essential needs of the Army. The joint UAV program supports the UAV needs of the Army. After a slow start, the joint UAV program is proceeding rapidly. Barring funding constraints, the Army, and the other services, will soon possess an operational short-range (out to 150 km) UAV system capable of performing tactical intelligence collection.

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I would like to express my sincere appreciation to the members of my thesis committee - COL Charles A. Endress, MAJ James M. Adams, and MAJ Daniel H. Page. Without their assistance this study would not have been written.

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CHAPTER ONE

STUDY DESCRIPTION

Introduction

The need to collect information on the composition and location of the enemy force has existed since Wellington maneuvered his forces behind hills, out of sight of the enemy commander. The use of aerial observers has long been recognized as a means to collect this information. With the advent of the airplane and aerial photography came the idea of using unmanned aircraft carrying cameras to photograph the enemy forces below.

Armies have long recognized unmanned aircraft as a relatively low cost, low risk method to collect information on an unfriendly or enemy force. The United States Army has attempted to develop and field an unmanned aerial vehicle (UAV) to conduct intelligence collection missions since 1952. UAVs are well suited to flying into high threat areas denied to manned aircraft and completing the mission.

The United States Army recognized this possibility as early as World War I. However, after years of trying to

develop an UAV to serve as an intelligence collection platform, the United States Army is one of the few modern armies in the world today not having an operational intelligence collection UAV.

When compared with manned aircraft, UAVs are relatively simple, small, and inexpensive to produce and operate. Being unmanned they are well suited to the roles of targets for air-to-air and ground-to-air weapons training and intelligence collection over enemy controlled territory. For the purpose of this research, UAVs are studied in their role as an intelligence collection platform.

An UAV designed for intelligence collection usually consists of five major systems. These are the aircraft itself, the mission payload (such as a camera), the radio data link used the transmit control signals from the ground to the aircraft and pictures from the aircraft to the ground, the ground control station from where the operator controls the aircraft, and a launch and recovery section that launches and lands the aircraft.

Figure 1 depicts a typical intelligence collection UAV, the Pioneer. Being evaluated as part of the Joint UAV Program, the Pioneer typifies many UAV designs. With a wing span of 16.9 feet, an overall length of 14.0 feet, and a maximum takeoff weight of 429 pounds, the Pioneer can collect real-time imagery information for up to five hours.[1]

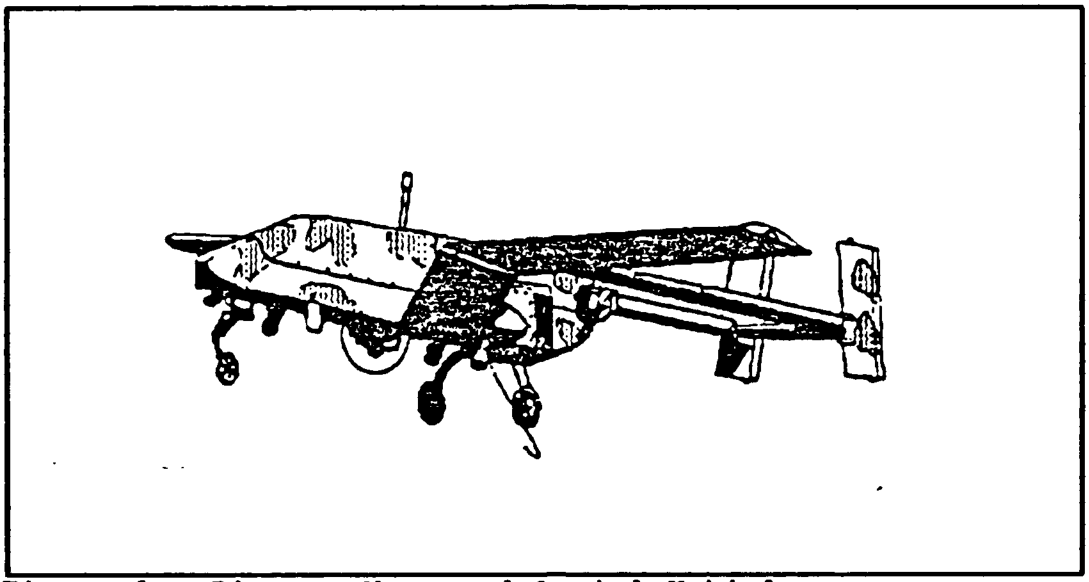

Figure 1 - Pioneer Unmanned Aerial Vehicle

The definition of unmanned aerial vehicles includes both the categories of remotely piloted vehicles and drones. A remotely piloted vehicle is flown by an operator located at a ground control station using a radio link to the air vehicle to control its flight. Drones are unmanned vehicles that accomplish flight through a set of instructions stored on-board the air vehicle. Since the cancellation of the AQUILA RPV program, the term UAV has been used to more accurately reflect the wider range of systems being developed.

After years of apparently wasteful and uncoordinated effort by the separate military services, the United States Congress froze all funding for existing UAV programs. The following passage from the 1988 UAV Master Plan summarizes the results of the Congressional directive.

> In FY 1988, the United States Congress eliminated separate program elements from the budget for remotely piloted vehicle (RPV) programs within each of the military Services, consolidated these efforts in a Joint RPV Program in the office of the Secretary of Defense, and authorized and appropriated reduced levels of RDT&E and procurement funding for such activities in FY 1988. In addition, the Congress directed that FY 1988 RDT&E funding: '...is available only for the Joint Remotely Piloted Vehicles (RPV) Program and may not be obligated or expended until the Secretary of Defense submits to the Committees on Appropriation of the Senate and the House of Representatives an updated master plan fully explaining his decisions as to which RPVs will be supported with the available funds and assessing the cooperation by the military Services with efforts to coordinate RPV programs and to eliminate duplication within and among the programs..' (Title IV, Public Law 100-180).[2]

The result of this legislation was creation of the UAV Joint Program Office (UAV-JPO) to integrate the efforts of the various agencies of the Department of Defense. The first task of the new UAV-JPO was to publish a UAV master plan. This was completed in June 1988. The master plan consolidates the UAV requirements of all the services. It issues in their place a single set of requirements for the future development and acquisition of non-lethal UAVs for the Department of Defense. The master plan proscribes a family of common UAVs to meet the requirements of all services. As might be expected, the requirements developed by the joint program differ from those of the original service programs.

After many years work of defining its UAV requirements, the Army was near the final selection of an

UAV system in 1987.[3] The Army had learned many lessons during its long history of UAV development and trials. With the experience gained from the AQUILA and other, more successful, programs, the Army was near the award of an UAV contract. During the summer of 1987 the Army was involved in the fly-off of three different UAV systems. These systems were competing for award of the Army long-range UAV contract. The Army's attempt to field an intelligence collection UAV was halted by Congressional action just as it was about to bear fruit.

The Army started its most recent attempt to field an UAV in 1975. At the time, the Army foresaw the requirement for a system capable of acquiring and designating targets beyond the normal line of sight of ground forces. The Army required this capability to support the new family of laser guided munitions then being developed. Without a means of accurately targeting the new weapons, their effectiveness was much diminished. This concept developed into the ill-fated AQUILA Remotely Piloted Vehicle (RPV) program.

Designed to find and designate targets for the new family of laser guided munitions, AQUILA started life as a sound program. However, over the years the program took on a complexity of staggering proportions.

The first operational tests of AQUILA conducted by the Army revealed several deficiencies in the system. Lockheed, the prime contractor for AQUILA, offered to fix

the problems with its own money and asked for another test. The Army agreed and conducted additional testing during 1987 at Fort Hood, Texas. Even with the improvements, AQUILA proved to be too complex and expensive for the task at hand. After 15 years of development, and the investment of over $750 million of funds, the US Army cancelled the program.

While the AQUILA program was being developed as a field artillery system, the intelligence community of the Army began to relook its UAV requirements. UAVs were obviously well suited to conducting intelligence collection tasks over the battlefield. The changing nature of the modern battlefield and the recent 1982 Israeli experience with UAVs spurred further research. Increased funding of military programs in the early 1980s was undoubtedly an additional factor adding impetus to the program.

The initial result of this effort was the identification of three classes of UAV. These classes were the target acquisition, designation and reconnaissance system (TADARS), the close range maneuver UAV (UAV-M), and the longer range intelligence and electronic warfare UAV (UAV-IEW). AQUILA was the TADARS class UAV. However, AQUILA was primarily a field artillery system rather than an intelligence collector. The AQUILA had requirements for precise location information and target designation with its on-board laser system. These unique features placed it in a category separate from the two intelligence collection

systems. The TADARS category was defined to provide for this difference in operational roles.

The maneuver UAV (UAV-M) was to be a small, lightweight, and low cost system. It would give battalion and brigade commanders the ability to see over the next hill. This capability would allow commanders to conduct reconnaissance of terrain and forces formerly hidden from view. The Army defined UAV-IEW as a system for the division and corps commanders. It would give them the ability to conduct intelligence collection up to 300 km (about 185 miles) behind enemy lines.

The cancellation of the AQUILA program in 1987, clarified the UAV situation for the Army. The new UAV-Close combined the TADARS and the UAV-M into a single category. No longer would two different systems, controlled by different headquarters, be operating in the same area. UAV-Close was to provide information for both situation and target development for the battalion through division commanders. The range of this class was 30 km forward of the front line of troops (FLOT). A mission endurance of three hours was required. The former UAV-IEW was redesignated the UAV-Deep. Its role was to collect intelligence information in support of deep operations at the division and corps level. This included the functions of both situation and target development. The range of this system remained 300 kms. This was the status of the Army

UAV program when Congress directed the integration of the service programs a single joint program.

The UAV Master Plan considered the requirements of the various services and combined them into four classes of joint UAV. The UAV-JPO decided requirements for range were the best way of determining classes for the new family of UAVs. These were defined as the joint close-range (JUAV-CR), short-range (JUAV-SR), medium range (JUAV-MR), and endurance (JUAV-E) classes of UAV. The endurance class UAV was named for its long endurance flight times.

The establishment of the joint program halted work on all Army programs. It forced a review of requirements and procedures throughout the Department of Defense. The reorganization of the UAV program caused a delay of at least two years in the Army UAV program.

Problem Statement

The Army developed requirements for its family of UAV-Close and UAV-Deep systems do not directly correspond to the UAV categories defined by the Unmanned Aerial Vehicle Joint Program Office. This study was undertaken to determine whether the joint requirements for UAV development adequately meet the intelligence collection needs of the United States Army.

The Research Question

Do Department of Defense specifications for unmanned aerial vehicles (UAVs) adequately satisfy United States Army requirements for intelligence collection UAVs?

Significance of study

Without a well defined set of requirements, neither the Army nor the other services will ever obtain an UAV system capable of meeting their actual needs. A faulty analysis of requirements will lead to developing a system able to meet paper requirements, but unable to accomplish the real mission. The UAV-JPO is the agency responsible to establish these requirements. Therefore, the UAV-JPO analysis of requirements must be correct if the Army is to obtain a system that works.

Research Objective

The objective of this research is to determine if the joint UAV program will satisfy the tactical intelligence collection needs of the Army. The requirements established by the Army and joint UAV programs are identified and compared. Discrepancies between the two programs are

analyzed to determine the impact on the performance of Army UAV missions.

Definitions

Unmanned Aerial Vehicle (UAV) - A term that includes unmanned aerial vehicles that are either remotely piloted or automatically piloted.[4]

Nonlethal - Not causing permanent damage or destruction. Includes UAVs with electronic combat (jamming) payloads.[5]

Remotely Piloted Vehicle (RPV) - An unmanned air vehicle controlled by a person from a distant location through a communications link, normally designed to be recoverable.[6]

Area of Operations - That portion of an area of war necessary for military operations, either offensive of defensive, pursuant to an assigned mission, and for the administration incident to such military operations. Usually assigned by the higher headquarters in the form of unit boundaries.[7]

Area of Interest - That area of concern to the commander, including the area of operations, areas adjacent thereto, and areas extending into enemy territory to the objectives of current or planned operations. This also includes areas occupied by enemy forces who could jeopardize the accomplishment of the mission.[8]

DOD - Department of Defense

FLOT - Forward Line of Own Troops. A line which indicates the most forward position of friendly forces during military operations at a specific time.[9]

JPO - Joint Program Office

RFP - Request For Proposal

ROC - Required Operational Capability. A document stating the needed operational requirements of a desired item of equipment or system.

RSTA - Reconnaissance Surveillance and Target Acquisition. A functional battlefield mission area.

Situation Development - The basic process by which intelligence is developed. The product of situation development is an understanding of the general location and capabilities of enemy forces. It provides an estimate of the situation and a projection of enemy intentions in sufficient time to permit the commander to select the most effective friendly course of action.[10]

Target Development - A process, based on situation development, of providing direct combat information, targeting data, and correlated targeting information. It provides the commander with timely and accurate locations of enemy weapons systems, units, and activities which may impact on current or projected operations.[11]

O&O CONCEPT - Organizational and operational concept. A document stating the way a particular unit of system is envisioned to be organized and operate when fielded. It

provides a general idea of how the unit will be employed during operations.

Background

The United States Army has a long history of investigating the use of Unmanned Aerial Vehicles as intelligence collection platforms.

Unmanned aircraft have demonstrated their potential to support military operations since World War I. First used as aerial target drones, these simple, remotely controlled, aircraft were soon pressed into service as unpiloted aircraft carrying an explosive payload to a designated target. The Army first experimented with powered, unmanned aircraft in 1915. Under the direction of Charles F. Kettering, a powered biplane carrying 180 pounds of explosive was flown three years later. This primitive aircraft (the Kettering Bug) was designed to fly to its target 40 miles away at 55 miles per hour. Guided to the target by pre-set flight controls, the wings would release and the fuselage would fall to the ground acting as a bomb. While not operationally successful due to terrible accuracy, the experience gained from the "Bug" did contribute to later efforts.[12]

The first successful droning of an aircraft followed in 1928. A radio-controlled, bomb-carrying Curtiss Robin

monoplane flew for four years until funds for the project expired in 1932.[13]

In 1938 interest in unmanned aircraft was again revived in the United States. Charles Kettering again entered the picture. Working with General H.H. Arnold, they headed a program to develop a new series of remote controlled weapons. The most successful of these projects was the GB-1 glide bomb. The GB-1 was a standard 2000 pound bomb with plywood wings and rudders attached. Dropped from heavy bombers beyond the reach of enemy air defenses, the glide bombs were visually tracked and radio-controlled into the target. The Army Air Force employed these weapons in mass against the German city of Cologne in 1943 with limited success. Also during World War Two, the Army investigated the idea of droning old B-17s and B-24s. The idea was soon dropped due to the cost of reconfiguring the old bombers.

Of course, the allies were not the only powers developing unmanned aircraft during the war. The Germans are well known for their development of the V-1 and V-2 series of unmanned aircraft. These aircraft were the forerunners of the modern cruise and ballistic missiles.[14]

After the war, the Army developed unmanned aircraft as target drones for anti-aircraft training. One of these drones became known as the radio controlled aerial target (RCAT). The RCAT become the most fired at, low altitude target during the 1950s. In 1953, COL Sam Webster, chief of

the Battle Area Surveillance Department of the US Army Electronic Proving Ground, installed a camera on a RCAT then used it to photograph maneuver forces. This demonstration was enough to convince the Department of the Army to develop a reconnaissance drone.[15]

By 1955 the Army had developed the AN/USD-1 reconnaissance drone. Aerial Surveillance and Target Acquisition platoons were established within each armored and infantry division, separate brigade and armored cavalry regiment. The USD-1, later designated the AN/MQM-57, soon developed into the improved AN/MQM-58A, giving improved range and more precise navigational accuracy. However, for safety reasons, the drones never participated extensively with manned aircraft or over friendly troops during training exercises. In 1963, due to cost overruns, and technical problems, the US Army ended the surveillance drone program. However, work continued within the Air Force and the Navy.[16]

During 1959 the United Stated Air Force started planning the conversion of highly successful BQM-34A target drones to carry photo-reconnaissance cameras over denied territory. With a planned range of over 1000 miles and flying at an altitude of 50,000 feet, the modified BQM-34A was considered an alternative to the U-2 manned reconnaissance program.[17]

On July, 8, 1960, the Soviet Union shot down a RB-47 SIGINT collection flight over the Barents Sea. One week

later, Ryan Aeronautical Company received a contract from the Air Force to demonstrate the feasibility of an unmanned reconnaissance platform.[18] The 1 May 1960 shoot down of the U-2 piloted by Gary Powers over Soviet territory gave the program added impetus.[19] The loss of U2 aircraft over Cuba during the Cuban Missile Crisis in Oct-Nov 1962, gave the unmanned reconnaissance program an additional boost. Only two reconnaissance drones were available and were nearly committed to action. This incident led to the contract for the Ryan 147B, the first true reconnaissance drone.[20]

In August 1964 the Air Force directed the deployment of the drone Task Force to the Philippines to support the Vietnam War. The drones supported the war effort there for almost eleven years.[21] The employment of the Ryan 147 family of drones over China and Vietnam during the war years was code named the BUFFALO HUNTER program. Carrying photo reconnaissance and SIGINT payloads, the reconnaissance drones developed an impressive mission record. In all, the 100th Strategic Reconnaissance Wing flew 3435 operational sorties in Southeast Asia. Designed with a life expectancy of only 2.5 missions each, the drones averaged over seven combat missions each. The record holding drone "Tom Cat" was lost after flying a record 68 missions. The longest mission flown logged 7.8 hours[22] Obviously, the drone concept had proved its usefulness.

The successful use of UAVs by Israel in 1973 and 1982 place the Israelis in the forefront of UAV development. In 1973, the Israelis used target drones to overload the Egyptian air defenses opposite the Suez canal. The expendable drones were used to saturate the Egyptian air defense system. By presenting the defending Egyptians with a large array of targets, the Israelis forced the Egyptians to deplete their surface to air missile (SAM) supply. this action then allowed the manned aircraft to pass through the air defenses as the SAM batteries reloaded.[23]

During 1981 Syria installed the highly regarded SA-6 in Lebanon's Bakaa Valley. Improving on the techniques learned during 1973, Israel flew in drones to evaluate the effectiveness of the SAMs. It can also be assumed that while SAM batteries were tracking and engaging the drones, intelligence collection assets were gathering information about the electronic parameters of the Syrian radars. Not only did the drones assist in evaluating the effectiveness of the surface-to-air missiles, they lured the Syrians into firing so that other RPVs could locate and target the firing positions for destruction by manned aircraft.[24]

After delivering such performance during the Vietnam War and in Lebanon, one wonders why the Air Force did not develop drones to their full potential. One of the key reasons RPV research moved so slow was the security blanket placed over the experiences of the 60's and 70's. A 1981

report by the GAO used words like "apathy" and "unawareness" to characterize the Pentagon's view of RPVs.[25] The bias toward manned systems has also impeded the growth of unmanned systems. Technology has blossomed with solutions to early RPV problems. At the same time, the risk of overflying hostile terrain has increased. Yet the bias for manned systems appears to continue.[26] Unmanned programs have come under the purview of aviators, where they compete for the same monies as manned programs. As a result, any aviator pushing for a RPV program may be imperiling his own future.[27] In the words of Benjamin Schemmer in the foreword to William Wagner's Lightning Bugs and other Reconnaissance Drones, "RPVs may have met their enemy. Could it be us?".[28]

Limitations

The best method of determining whether the joint UAV program will satisfy the needs of the Army is through testing in combat operations. This approach is obviously not preferred. This study researches the topic based on current knowledge and our understanding of the future battlefield as we expect it to be.

The conduct of this study as an unclassified project limits the ability to address specific collection requirements and abilities. Collection opportunities against threat targets, as well as current collection

capabilities, are examples of these limitations. However, these are addressed without specifics and still achieve the desired result. Where specifics are not presented, the classified source is referenced for further study by readers having the necessary security clearance.

Delimitations

This study excludes lethal UAVs and UAVs intended for purposes other than reconnaissance, surveillance, and target acquisition. This study does not focus on reference material related to UAV or RPV programs before 1985. However, any material available before this time is reviewed for background information.

Assumptions

AirLand Battle Doctrine as discussed in Army Field Manual 100-5 will remain the war fighting doctrine of the US Army. A recent reevaluation of AirLand Battle completed this year has revalidated this doctrine for the next 10 to 15 years. The intelligence collection requirements of the Army will not change appreciably in the mid-term. This study assumes the UAV technologies in use throughout the world is available for the manufacture of systems in the United States.

Methodology

The methodology used to conduct this study is a qualitative comparison of the Army and joint UAV program requirements. Army requirements published before establishing the UAV Joint Program Office are compared to joint requirements. The resultant difference, if any, between the two sets of requirements determines whether the joint program supports the needs of the Army.

The research methodology consists of four steps. The first step is identifying the stated requirements of the Army and joint UAV programs. Required capabilities statements, system specifications, and system concept papers are used to identify the specified UAV requirements. The second step of the methodology is the Army requirements for validity. The constantly redefining of UAV requirements by the Army and objectives of this study dictates this additional step.

Comparing the specified requirements of the Army and joint programs is step three. Differences between the two programs are identified in this process. Comparison tables are used to display this data. Determining what impact the discrepancies between the Army and joint programs have on the Army UAV mission is the final step in the research process. This approach is selected based on the structured and qualitative nature of the research.

Organization of the Study

Chapter One is a general description of the study. Included in this chapter are the introduction, problem statement, significance of the study, and research objective. Definitions, limitations, delimitations, assumptions, a brief description of the research methodology, and study organization are also addressed.

Chapter Two is a review of the literature and documents available related to the research. Included in this chapter is a comprehensive summary and brief evaluation of existing research on the subject of UAV requirements. Also included is information on other countries' experiences with UAVs/RPVs as intelligence collection platforms.

Chapter Three presents a detailed discussion of the methodology developed to conduct this research. The general research approach and the specific techniques used are discussed in this chapter. How research progressed through the study is also addressed.

The findings of this study are discussed in two chapters. The findings validating the UAV requirements of the Army are presented in Chapter Four. The discussion also explores the Army need for an UAV. Chapter Five presents the match up of the joint specifications against the capabilities specified in the Army required capabilities documents.

Chapter Six is a summary of the study. It contains the conclusions and recommendations presented as a result of this research. The ability of the joint program to satisfy the needs of the Army is addressed in this chapter. Recommendations on how to improve the Army and joint programs are also provided. Recommendations identifying areas needing further research are made.

CHAPTER ONE

ENDNOTES

[1]US Army Intelligence Center and School, Unmanned Aerial Vehicle Operations (Coordinating Draft), Field Manual (FM 34-25-2) (Ft Huachuca, AZ, August 1989), 4.

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[8]Ibid., 1-8.

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[10]Department of the Army, Intelligence and Electronic Warfare Operations, Field Manual (FM 34-1) (Washington, D.C.: United States Government Printing Office, 31 March 1984), 1-2.

[11]Ibid.

[12]Donald W. Cairns, "UAVs - Where we have been," Military Intelligence (March 1987): 18.

[13]Ibid.

[14]Ibid., 19.

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[19] Cairns, 19.

[20] Wagner, 42.

[21] Cairns, 19.

[22] Wagner, 200.

[23] Benjamin F. Schemmer, foreword to Lightning Bugs and other Reconnaissance Drones (California, Aero Publishers, Inc., 1982), ii.

[24] Ibid.

[25] Schemmer, iii.

[26] Ibid.

[27] Ibid.

[28] Ibid., iv.

CHAPTER TWO

REVIEW OF LITERATURE

Introduction

The primary purpose of this chapter is twofold; first, to review the status of existing research, and secondly, to identify the gaps in current knowledge this study will attempt to fill. A secondary purpose is to identify the scope of materials researched to complete this study. This chapter is organized into five sections.

The first section is an examination of the documents identifying stated UAV requirements of the Department of the Army and Joint DOD programs. The Joint DOD UAV Master Plan is examined in depth in this section.

Section two addresses the available literature providing background information on the subject of RPVs and UAVs in general. This information was quite useful in forming my initial understanding of the topic and helping establish the scope of the research topic. This section includes an examination of literature describing the historical perspective of UAV development and use by the

military services of the United States. Included is a review of congressional documents available on the subject of RPVs and UAVs. This large source of information provides valuable insight into the history of RPV/UAV development by the separate services and serves to clarify the decision process behind the congressional directive to develop a joint UAV program office.

Section three is a review of literature describing US Army doctrine guiding intelligence collection and the tactical intelligence collection shortfalls of the United States Army. This section also includes a review of literature describing the current capabilities of UAV technologies and the current state of UAV development in other countries.

The fourth section is a review of academic research conducted in the area of UAVs for the purpose of intelligence collection.

The fifth section identifies gaps in existing research and addresses the role this study may have in helping to fill those gaps. A short summary completes the chapter.

Research for this study considered all material relevant to the subject of unmanned aerial vehicles and their development as intelligence collection platforms. Material dating back to the first use of unmanned aircraft as a military tool was used for the development of

historical information. However, only material published during 1985 and later was used to conduct the analysis of requirements for current UAV programs. This was done to concentrate the study on the evolution of current requirements and not focus on the period of time when requirements were evolving and changing on a daily basis.

The complete assistance of the research staff of the Combined Arms Research Library (CARL) of the US Army Command and General Staff College, Ft Leavenworth, Kansas, was of great help in this effort. The CARL automated card catalog, the Reader's Guide and National Technical Information Service (NTIS) database were very useful. The Defense Technical Information Center (DTIC), dissertations abstracts, and COMPANDEX(tm) databases were also searched to locate any academic studies conducted on the topic.

Research of Army and DOD Requirements

The primary research question forming the core of this study requires an analytic comparison of the UAV requirements of the Army and the Joint Program Office. To accomplish this research, the requirements had to be identified, located, and thoroughly researched. Documentation providing the data for this challenge was obtained through the office of the TRADOC Combined Arms

Combat Development Activity (CACDA), located at Fort Leavenworth, Kansas.

Located within CACDA is a new organization. This is the TRADOC Program Integration Office (TPIO) for Tactical Missile Defence, Deep Operations and Reconnaissance, Intelligence, Surveillance and Target Acquisition (RISTA). Formed by the Vice Chief of Staff of the Army, GEN Thurman, in 1987, TPIO-RISTA is charged with the task of integrating all programs in the reconnaissance, intelligence, surveillance, and target acquisition functional mission area. TPIO-RISTA oversees and coordinates all UAV activity in the Army.

From TPIO/RISTA were obtained copies of the UAV Joint Program Office DOD JOINT UAV PROGRAM MASTER PLAN and the organizational and operational plans and the required operational capability statements for the Army UAV-Close and UAV-Deep programs.

The Joint UAV Master Plan, published by the Joint UAV Program Management Office in June of 1988, is the authoritative source for published requirements established by the DOD. The Master Plan is the source of non-lethal UAV requirements for the Department of Defense. The Master Plan serves as the Capstone document for the generation of all requests for proposals for UAV systems. Operational and organizational concepts as well as required operational

concepts are based on requirements as stated in the Master Plan.

The Master Plan describes the overall DOD strategy for UAV development and procurement. The coordination between the services and a description of their respective roles within the joint managed program are detailed in Section II of the plan.[1]

The Master Plan outlines requirements for a family of four classes of UAVs. These are the Joint Short Range, Close Range, Medium Range, and Endurance classes.[2] The discriminators of range and endurance were selected as the basis for class determination because they were the common denominator found in the original requirements statements of the separate services prior to the formation of the UAV Joint Program Office.[3]

The original master plan stated requirements for each of the four classes of UAV in terms of operational capabilities, launch and recovery methods, radius of action (range), speed, loiter time, information timeliness, sensor type, air vehicle, ground station, data link, and crew size.[4] The master plan also addresses the acquisition strategy for the eventual procurement of all four classes of UAVs.[5]

Before Congress directed the formation of the Joint UAV Program Office, the United States Army had finished the development of requirements for a family of UAVs to use as

intelligence collection platforms. In order to meet the varied requirements of intelligence collection, two categories of UAVs was developed. These were the UAV-Close, and UAV-Deep.

The operational and organizational (O&O) plans and required operational capabilities (ROC) statements for the Army UAV-Close and UAV-Deep programs provide a more detailed definition of requirements for Army programs than those given in the Joint Master Plan for the DOD programs. Given the availability and conciseness of these documents, the analytic comparison of the two sets of requirements can be accomplished.

Background Information

Three periodicals routinely carry excellent articles providing the current and near future status of virtually all UAVs and sensor payloads in the world. These are Aviation Week and Space Technology, International Defense Review, and Armed Forces Journal International. All three are excellent sources for up to date changes in the area of UAVs.

The technical capabilities of current UAV systems are thoroughly documented. Two excellent sources of such information are Jane's Publishing World Unmanned Aircraft and Unmanned Aircraft (Brassey's Airpower: Vol III),

published by Brassey's Defense Publishers Ltd. Both publications contain good histories of the development of UAVs by many countries of the world, to include many successes. Existing literature is more than adequate to determine the current capabilities of air vehicles and sensor payloads.

Historical Perspective

Several excellent references are available to trace the history of UAV development. Both Jane's Publishing World Unmanned Aircraft and Unmanned Aircraft (Brassey's Airpower: Vol III), published by Brassey's Defense Publishers Ltd offer good histories of the development of unmanned flight. William Wagner's Lightning Bugs and Other Reconnaissance Drones provides a detailed account of drone operations conducted in Southeast Asia during the Vietnam War. This was the United States' pinnacle of UAV development. An article by Donald Cairns "UAVs - where we have been" provides a fascinating look at the long history the United States Army has enjoyed in UAV development. UAVs for the purpose of intelligence collection is not a new concept for the armed forces of the United States.

A wealth of background information on the development of the Joint UAV program exists in the records of Congressional hearings and testimony before the House and

Senate Armed Services and Appropriations Committees. A study of these documents reveals the Congressional attitude toward the ill-fated AQUILA program and a sense of service reluctance to fully develop UAV programs. Of particular interest in these documents is the DOD testimony as to why UAVs are required to support the defense effort and how the many different programs of the past were in reality uncoordinated and wasteful.

This study of the Congressional records reveals the necessity for the creation of a joint agency to oversee and coordinate the development of numerous UAV development and acquisition programs. With an understanding of how the joint program was created, one can understand the structure of the UAV Master Plan and the considerations for developing joint requirements.

Analysis of Army Requirements

The second step of the research methodology requires testing the validity of Army UAV requirements. Did the Army correctly identify its requirements for an intelligence collection UAV? The answer to this question will validate the Army requirements for the Army UAV-Close and UAV-Deep. Investigating the manner in which the Army requirements are developed helps answer this question.

The basis of all war fighting doctrine for the United State Army is AirLand Battle. This doctrine is published as Field Manual (FM) 100-5, Operations. The development of all war fighting concepts, weapons, systems, and organizations, is derived from this capstone doctrine.

The basis of doctrine for the conduct of intelligence support to the tactical level of war is described in FM 34-1, Intelligence and Electronic Warfare Operations. FM 34-1 discusses how military intelligence operations function to support the commander. This manual, in conjunction with FM 100-5, Operations, provides the basic criteria for what information must be collected.

The actual techniques and procedures used to plan, direct, and control the collection effort is a process defined as collection management. This process is described in FM 34-2, Collection Management. FM 34-2 provides the basis for how the intelligence collection process is directed, managed and executed. The basis for determining general collection requirements is provided by both FM 34-1 and FM 34-2.

The Army intelligence collection requirements for both the current time and the near future are stated in the Army Intelligence Master Plan (AIMP). The AIMP is the US Army blueprint for tactical intelligence operations through the year 2004. It outlines the expected nature of the

threat and the desired organization and capabilities of military intelligence units over the intervening years.

The Army foresees a large role for intelligence collection UAVs starting in the near future. A recent article in the service oriented periodical, Army Times, states that, based on a recently released assessment of the world UAV market conducted by the Market Intelligence Research Company, Mountain View, California, the UAV market is poised at the current time to boom over the next decade. "Revenues of the defense companies in the UAV Business are expected to increase from $120 million in 1989 to more than $650 million by 1998, the study predicts."[6]

A secondary research step is determining the tactical intelligence collection shortfalls of the US Army. Determining whether or not UAVs are required to satisfy any of these requirements assists in validating the Army's UAV requirements.

"The Army Battlefield Functional Mission Area Analysis" identifies the capability shortfalls for each of the seven battlefield operating systems. Intelligence is one of the seven operating systems. This mission area analysis identifies current tactical intelligence collection shortfalls. Some shortfalls exist because of the total lack of systems capable of collecting the required information. Other shortfalls exist due to the inadequate performance of currently fielded systems.

It is interesting to note that every major military power in the world, and numerous third-world countries, possess operational intelligence collection UAV systems. The Soviet Union, our NATO allies, and Israel, stand out as possessing mature UAV programs. The experience of the countries has done much to influence the development of UAVs within this country. The UAV Joint Program Office is actively pursuing the evaluation of several foreign systems for possible service in this country.[7]

The Soviet Union has already fielded an operational reconnaissance drone system. Known to NATO as the DR-3, this drone is a medium range system capable of down-linking real-time imagery to ground unit commanders. A newer version is believed to possess even greater capabilities.

Within the NATO alliance, virtually all countries except the United States are operating reconnaissance UAVs. The need for such systems is the same that drove the United States to develop the AQUILA system. This is the requirement to target enemy formations beyond the front lines.

Academic Studies

Numerous academic studies on the subject of UAV development exist. The vast majority of these studies focus on the technical and engineering problems of unmanned

flight. Very few studies research the actual requirements for unmanned vehicles. I have found only two graduate level studies contributing to this research.

Unmanned Vehicles to Support the Tactical War, written by Lieutenant Colonel David H. Cookerly, May 1988, was completed in fulfillment of a research requirement to the Air War College. This study is a very broad look at the possible role UAVs might play in supporting the Air Force tactical mission.

Lieutenant Colonel Cookerly examines the Israeli use of unmanned aerial vehicles in the 1982 Lebanon operation and traces the history of unmanned vehicles in the tactical arena. The author then proceeds to lay a foundation for a review of current and planned systems and missions.

In his study the author only briefly acknowledges the reconnaissance role as a primary mission for the UAV. Appendices describing UAV systems available in 1988 account for approximately two thirds of the study.

Unmanned Air Vehicles - Real Time Intelligence Without the Risk, written by Lieutenant James B. Miller. This study is a Master's thesis completed for the Naval Postgraduate School in March 1988. Lieutenant Miller asserts the UAVs now in development are capable of providing the naval commander with near-real-time high resolution imagery. In his thesis, Lieutenant. Miller states,

> "that UAVs should be used to supplement existing intelligence sensors, particularly in those cases

where current sources are too ambiguous, slow, dangerous or take [manned] resources away from their primary duties."[8]

Lieutenant Miller addresses the UAV question from the Navy point of view. His findings support the Navy Department's statement of requirements for UAV use.

Analysis of Existing Research

Despite the amount of research material available on the topic of UAVs, there does not exist any published study comparing the Army UAV requirements with those developed by the UAV Joint Program Office. As I have discussed, the basic data for conducting a comparison of Army developed requirements versus those of the joint program exist. However, no study has been conducted contrasting the two sets of requirements. Neither could I locate a similar study accomplishing the same for the other services. This study will address this gap in research and identify any discrepancies between the two programs.

Summary

Adequate literature exists allowing the proper conduct of this study in accordance with the selected research methodology. Much has been published on the projected future of unmanned aerial vehicles and the

possible roles they might play. The vast majority of this material has focused on the technical side of the matter. While it is widely accepted that UAVs are an integral part of the future of intelligence collection, little has been written on what is actually required to augment the capabilities already present in the other systems of today.

The US Army itself has struggled for over ten years to develop a set of requirements for UAVs. Unfortunately, rapid advances in supporting technologies, funding restraints, political infighting, and biases toward manned aircraft have all combined to slow progress. This study focuses on identifying the requirements of the Army and investigating whether or not those needs are supported by the Joint DOD Master Plan.

CHAPTER TWO

END NOTES

[1]Tactical Intelligence Systems Directorate OASD (C3I), DOD JOINT UAV MASTER PLAN, 1988 (The Pentagon, Washington, D.C., 27 June 1988), 5.

[2]Ibid., 25.

[3]Ibid.

[4]Ibid., 26.

[5]Ibid., 36.

[6]"Unmanned aerial vehicle market poised to boom," Army Times, 11 December 1989, p. 26.

[7]UAV Joint Program Office, Unmanned Aerial Vehicle Master Plan - 1990 Update, (Department of Defense, Washington, D.C., 26 January 1990), ii.

[8]James B. Miller, Unmanned Air Vehicles - Real Time Intelligence Without the Risk (Naval Postgraduate School, Monterey, California, March 1988), iii.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

This chapter describes the research methodology developed to conduct this study. An understanding of the methodology will help readers assess the validity of the conclusions and assist in the conduct of related research.

This chapter consists of four sections. Section one is the introduction, it states the purpose and organization of the chapter. The methodology developed to conduct the research and the specific techniques used to develop the research data are outlined in the second section. Section three explains the purpose and construction of the comparison tables used to structure the research and organize the raw data. The fourth and final section addresses the identified strengths and weaknesses of the research methodology.

Explanation of Methodology

The intent of this section is to clearly and accurately describe the general research procedures and techniques used to conduct this study. This study is a critical comparison of Army UAV requirements versus those of the joint UAV program. This comparison identifies the differences in requirements between the two programs. Analysis of these differences answers the research question of whether or not joint UAV requirements meet the UAV needs of the Army.

The research methodology consists of four steps. The first step is identifying and qualifying the respective requirements of the Army and joint UAV programs. Validating the requirements of the Army is the second research step. The third step in the methodology is the identification of differences between the two programs. Determining the impact these differences will have on the Army UAV program is the final step of the research methodology.

Step 1. Identification of Requirements. The initial step in the research methodology is determining the UAV requirements of both the Army and joint UAV programs. Research of the requirements documents for the respective programs accomplishes this. The Required Operational Capabilities (ROC) statements for the Army developed UAV-

Close and UAV-Deep programs state Army UAV requirements. The UAV Master Plan states the general requirements for the joint program. System concept papers, mission need statements, and system specifications state more specific requirements for the various categories of joint UAV.

The Army published revised Required Operational Capability (ROC) statements for a family of UAVs in 1988. These ROCs outline an Army approach consisting of two categories of UAV. These are the UAV-Close and UAV-Deep systems. These two documents remain the Army's most current statement of its UAV requirements.

This study uses the UAV Master Plan as the source document for joint UAV program requirements. At the direction of Congress, the Department of Defense formed the UAV Joint Program Office (UAV-JPO) in 1988. The purpose of the UAV-JPO is to direct the future development and procurement of non-lethal UAVs for the Department of Defense. Among the first task of the UAV-JPO was publishing a joint UAV master plan. Congress required submission of a master plan before it released any funds for UAV development or procurement. The UAV-JPO published the master plan in June 1988. It states requirements for the joint UAV program and outlines a procurement strategy to reduce duplication of effort.

The Joint UAV Master Plan outlines requirements for a family of non-lethal UAVs consisting of four categories of

unmanned vehicles. These are the joint UAV Close-range (JUAV-CR), Short-range (JUAV-SR), Medium-range (JUAV-MR), and Endurance (JUAV-E) categories of UAV. The JUAV-CR equates to the Army UAV-Close while the JUAV-SR category will be used by the Army as its UAV-Deep system.

Step 2. Requirements Validation. The second step in the research methodology is testing the validity of Army UAV requirements. To determine if the joint program satisfies the requirements of the Army, the requirements must be valid. Requirements must reflect the actual needs of the Army, not unfounded desires.

The validation step is necessary because of the many changes within the Army UAV program. Starting with development of AQUILA, the Army has constantly redefined its requirements while learning from the development process. These changing requirements have led the Army through a series of interim concepts to the current family of UAV-Close and UAV-Deep.

These many changes in the program invite claims the Army program is uncoordinated and its UAV role not clearly defined. When questioned by the House Armed Services Committee, representatives from the Office of the Secretary of Defense were unable to state a clear Army plan on how AQUILA would fit into the Army program.[1]

When Congress directed the formation of a joint office to manage the DOD UAV effort in 1987, they also specified that one UAV system be eliminated. Although AQUILA was not specified, it was the obvious choice.

Throughout the years of developing AQUILA the Army insisted it needed the advanced capabilities only the complex AQUILA offered.[2] Then, in July 1987, the Army cancelled the AQUILA program. At the same time the Army also eliminated the entire target acquisition and designation (TADARS) UAV from its program. The Army cited cost overruns and excessive system complexity as reasons for the cancellation.

The purpose of this study is to determine if the joint UAV program supports the needs of the Army. It is not within the scope of this study to determine if all joint program requirements are valid. However, this study will itself test to some extent the validity of the joint program.

Preliminary research revealed Army requirements for UAV development were in flux from 1984 through 1988. Driving these changes were the lessons learned during the development and initial fielding of the AQUILA system. Rapid technological development also contributed to these revisions.

The first test for stated requirements is determining if they support the Army's doctrine for providing tactical

intelligence support. Examining the required operational characteristics of the UAV against the principles of intelligence operations accomplishes this test. The Army field manuals IEW Operations (FM 34-1) and Collection Management (FM 34-2) describe the doctrine used to perform this test. The intent is to determine if UAV requirements support the Army's overall concept of fighting future conflicts.

The IEW mission area of the Battlefield Functional Mission Area Analysis (BFMAA) identifies the intelligence collection shortfalls of the US Army. Currently available, and demonstrated, UAV systems are used to determine present UAV technical capabilities. Examination of current UAV airframe, sensor payload, and data link capabilities determine the ability of UAVs to fulfill these collection tasks. Comparison of UAV capabilities against shortfalls listed in the Mission Area Analysis then establishes the validity of Army UAV requirements. Comparison of UAV requirements with the collection requirements stated in the IEW Master Plan further confirm the validity of the UAV program.

Step 3. Requirements Comparison. Comparing the Army requirements against those of the joint UAV program is the third step in the research methodology. The result of the comparison is identification of any differences between the

requirements of the two programs. Matching the required operational characteristics of the Army systems against the characteristics specified for the joint program accomplishes this task. The joint short-range UAV system (JUAV-SR) is compared to the UAV-Deep for its capability to fulfill that role for the Army. Likewise, the close-range JUAV-CR is evaluated against the requirements for the UAV-Close. The joint UAV medium-range (JUAV-MR) and endurance (JUAV-E) have no equivalent in the Army UAV program and are not evaluated.

All operational characteristics identified as being requirements for the Army UAV-Close or the UAV-Deep are selected as criteria for comparison. The required characteristics are identified from the Army ROCs and listed in a comparison table. The next section of this chapter discusses the comparison tables in further detail. The requirements of the joint program are then examined to identify an equivalent requirement in a joint category of UAV. Where found, they are then recorded as either exceeding, equalling, or not meeting the Army requirement. Any operational characteristics required by the Army, but not stated as a requirement in the joint program, are identified as shortfalls. Joint program specifications exceeding Army requirements fall outside the scope of this study.

This analytic technique possesses one identified problem. The ROC documents clearly state and define the

characteristics required of the Army systems. However, in many cases, the documents also state a desired characteristic. This practice keeps requirements at the minimum level necessary to accomplish the mission. At the same time, the Army is informing contractors of capabilities the Army desires, but does not consider essential to mission success. The comparison tables identify the required and desired characteristics.

Step 4. Impact Determination. Determining the possible impact identified shortfalls will have on the UAV missions anticipated by the Army is the final research step. This research step uses two primary tools are used to conduct this analysis. The first of these tools are the rationale statements provided in annexes to the ROCs for each of the required operational characteristics. Reapplying the tests of step two in the research methodology to test the validity of requirements is the second tool used.

Operational characteristics identified as shortfalls are first determined to be either a required or a desired capability. This determination helps assess the impact the shortfall will have on mission effectiveness. The rationale statement provided for the required characteristic is then used to determine the full impact of the shortfall. The next step in the impact assessment is examining the

shortfall by applying the same test used to test for validity. The goal is to determine if the reduction in capability will impact on the performance of a collection mission identified as an Army collection shortfall? Any reduction in the ability of the UAV to conduct these missions is a serious limitation.

With this analysis complete it is then possible to state the impact of the shortfall on overall UAV mission effectiveness. Chapter Six addresses the full impact of identified shortfalls.

The Comparison Tables

The research topic lends itself to a simple comparison of two sets of data. The first being the Army requirements for UAVs, the second, the joint UAV requirements. Since this study requires a straight comparison of data, a table format is selected as the tool to organize and display the data. The use of a tabular format allows quick examination of the data. Complex computer algorithms or statistical packages are not required.

A separate comparison table is used for each major sub-component of the UAV system. Examples of major sub-components are the air vehicle, the mission payload, and the

ground control station. Sample comparison criteria, identified in the requirements of both programs, are mission endurance and the maximum range at which the air vehicle must operate.

The comparison table identifies the requirements of the Army system, and states whether the joint specifications meet the needs of the Army. The tables serve only to readily highlight differences between the two programs. Chapter Six addresses the significance attached to any of the findings produced by the comparison process.

Strengths and Weaknesses

Two identified weaknesses exist in the research methodology. The first of these is the different philosophy used by the Army and the UAV JPO to state their respective requirements. In gener , the Army's statements of its required characteristics are more detailed and specific than equivalent specifications for the joint systems. This difference makes it difficult to assess whether or not a shortfall exists.

The second methodological weakness is the degree of subjective assessment involved in determining the impact of the shortfall. In many cases the actual impact of any shortcoming will not be apparent until the entire intelligence collection system is tested in a full scale

hostile environment. As a result, some degree of subjectivity remains in the process.

Simplicity is the base strength of the methodology. The simple problem-solving approach allows a research effort that is direct, easy, and understandable. Simple comparison tables are well suited to the task. The tabular nature allows an objective comparison of the requirements.

In summary, the strengths of the methodology outweigh the weaknesses. The methodology described in this chapter is determined to be the best approach to conduct the research required for this study.

CHAPTER THREE

ENDNOTES

[1]Congress, House, Committee on Armed Services, Procurement and Military Systems Subcommittee, Remotely Piloted Vehicles [RPV] Programs, 100th Cong., 2nd sess., 5 March 1987, 176-200.

[2]Ibid.

CHAPTER FOUR

ARMY UAV REQUIREMENTS

Introduction

The purpose of this chapter is to examine and discuss the development of Army UAV requirements. Discussion of how the joint UAV program supports the Army requirements is presented in Chapter Five.

This chapter is organized into five sections. First, is the introduction. Section two discusses the tactical intelligence collection needs of the Army. Discussion of how the UAV supports these needs is presented in section three. The fourth section presents findings as to the validity of the stated Army requirements. An overview of the joint UAV program is given in section five. The sixth and final section is a summary of the significant findings presented in this chapter.

Army Intelligence Collection Needs

The Army's intelligence collection system is driven by the capstone war fighting doctrine of the United States Army. The current doctrine, defined as "AirLand Battle" is defined and described in Army Field Manual (FM) 100-5, Operations.

AirLand Battle postulates Army operations in a non-linear, highly fluid environment, which places a premium on the ability of the maneuver commander to obtain the initiative and force the enemy to fight on unfavorable terms. This doctrine is based on four tenets of initiative, agility, depth, and synchronization.[1]

Initiative is the ability of the friendly commander to determine the terms of battle. It calls for the commander to be proactive, not reactive, forcing the enemy to react to our actions. Initiative means exercising individual judgment and conducting independent operations, but, within the framework of the higher commanders' intent. The exercise of initiative requires knowledge of the enemy's force, his deployment, and capabilities.[2]

Agility is the ability to react and respond to rapid battlefield changes. To support this agility, intelligence collection operations must be capable of being quickly redirected against new and unexpected threats. Dynamic tasking of collection systems is required.[3]

Depth is conducting the battle throughout the entire battlefield. Depth implies the planning and conduct of operations in depth of time as well as space. This means being able to engage the enemy force deep in his rear areas as well as influencing those forces moving forward that will impact on the next day's battle. To achieve depth on the battlefield intelligence sensors must be able to locate and identify the enemy force deep in his territory.[4]

Synchronization is the ability to not only coordinate the diversity of activities on the battlefield, but to also employ all assets at the best time to gain the synergistic effect of their combined action. Timing the employment of weapons and support systems is the key to synchronization. Accurate and timely intelligence information on the enemy forces will provide the required information to properly synchronize operations.[5]

FM 34-1, Intelligence and Electronic Warfare Operations, describes Army doctrine for conducting intelligence operations in support of Army operations. It provides the overall concept for intelligence operations supporting AirLand Battle. FM 34-1 describes the intelligence process as follows.

> Intelligence is developed through a process known as the intelligence cycle. The cycle consists of four phases: directing, collecting, processing, and disseminating. It is a continuous process, and even though each phase is conducted in sequence, all phases are conducted concurrently.

This study is concerned with the ability and need for UAVs to conduct collection of intelligence information.

Once the information requirements are known, assignment of collection assets is made. This decision process is based on five critical selection factors: range, timeliness, technical characteristics, environment, to include terrain and weather, and the enemy.[6]

These selection factors are evaluated against the capabilities of the available collection resources. Range is evaluated in terms of the distance of the targeted area of interest from the collection asset. A given resource will have a maximum range at which it can collect information. The target area must be within this range.[7]

Time available is determined by two factors. The commander requesting the information states how timely the information must be. Current methods requiring four to eight hours to process film and interpret photographs do not satisfy a collection tasking requiring the information within one hour of the event. The second part of the timeliness factor is the length of time the target area is vulnerable to collection. Targets vulnerable to collection for only one or two hours can not be collected against with systems requiring twelve to twenty-four hours lead time to request.[8]

Target characteristics determine what sensors are capable to collect the desired information. A well

camouflaged enemy unit may not be detectable with an imagery system. However, the same enemy unit, through the use of its radio transmitters may render it vulnerable to detection and location by radio intercept.[9]

Terrain and weather work together to create the environment in which collection operations are conducted. A high hill mass between friendly collection assets and the enemy may mask the enemy force from radio intercept operations. A low cloud ceiling could easily defeat attempts to obtain aerial photographs of the enemy positions.[10]

The enemy affects collection operations through his use of concealment efforts and the employment of weapons systems to deny collectors the positional advantage to conduct collection operations. Deception operations are another method the enemy will employ to defeat our collection effort. The best method available to see through deception operations is to use a variety of sensors. Using this technique sensors can confirm or deny the reports being rendered from a sensor system targeted by deception operations. The ideal collection system minimizes the effect the five selection factors will have on the employment of the system.[11]

Two additional factors govern the selection of collection resources. These are the principles of resource mix and redundancy. Resource mix is the principle of

employing different types of sensors to collect the same information. This assures a greater possibility of collecting the desired information. For example, an enemy unit may be observing radio silence thus denying the ability to determine its location through radio direction finding. However, the same unit may be located through aerial photographs taken form an overhead reconnaissance aircraft.

Redundancy involves assigning more than one collection resource of the same type to a target. Redundancy is used when the probability of collection by any one system is too low for collection to be reasonably assured.[12]

The current collection systems in use suffer several limiting characteristics. When combined, these factors impose significant limitations on the Army collection system. The inability to obtain photographs of enemy controlled terrain and of enemy units is the major weakness of the tactical intelligence collection system.

Several systems possess the technical capabilities required to collect imagery during daylight hours and periods of restricted visibility. Among these resources are Army MOHAWK aircraft, Air Force reconnaissance aircraft, and national level imagery collection platforms. Each asset is limited by one or more of the five selection factors, severely restricting the collection of imagery intelligence.

The Army airborne imagery platform, the OV-1D MOHAWK, is a reliable aircraft capable of aerial photography as well as other missions. However, the effectiveness of air defense weapons have forced the MOHAWK into a stand-off role because it cannot survive across the FLOT in a mid or high intensity conflict. As a result, the MOHAWK is scheduled for retirement from active service. As specified in the Army Intelligence Master Plan the MOHAWK will be gone from the Army inventory by 1995.

The Air Force platforms, typified by the RF-4 PHANTOM and the F-16 FALCON, possess the speed and agility to operate across the FLOT. Designed to attack targets in enemy territory they are capable of taking aerial photographs, but enemy air defenses make even reconnaissance missions a very risky business for the pilot.

Another serious limitation with Air Force resources is the time required to plan the mission and process the film, conduct interpretation of the photography, and transmit the gathered intelligence to the requesting unit. Slow response time and timeliness of reporting renders these assets useless for anything but reconnaissance of the most immobile targets such as road intersections and bridges.

Manned systems, because of the high risk incurred by the pilot and the effectiveness of current air defense weapons, are not capable of conducting continued surveillance of a target. To survive, the pilot must plan

his ingress and egress routes very carefully to minimize exposure in the target area. Multiple passes over a target, even in a short period, are extremely risky.

An additional source of imagery is from national level platforms. Although not dedicated to providing tactical level intelligence, these systems routinely produce large amounts of intelligence useful to the tactical commander. The Tactical Exploitation of National Capabilities (TENCAP) program provides the means of delivering this intelligence to the corps and division commander.

Until recently, these assets included the high flying SR-71 reconnaissance aircraft and satellite imagery systems. The SR-71 was phased out of service in March of 1990 for reasons of funding and its obsolescence in light of satellite capabilities. Satellites are relatively invulnerable to enemy air defense efforts and definitely possess the range to see deep into enemy territory. However, they suffer the same limitations of the Air Force systems, but to a greater degree.

The further removed from the requesting unit a collection asset is controlled, the less responsive it is to the needs of the maneuver commander. Another drawback of satellite platforms is the inherent lack of flexibility imposed on the system due to the physical laws of orbital

mechanics. Satellite coverage of a particular target area is fixed by the orbit of the satellite.

Another limitation of current collection systems is the radio line-of-sight restriction imposed on SIGINT collectors. The range of ground-based SIGINT collectors is severely limited by this restriction. Generally speaking, ground based SIGINT systems collecting in the VHF and UHF frequency range are restricted to a range of about 30 kilometers. When combined with the time required to move and reestablish these systems, it is hard to keep pace with rapidly moving situations.

Aerial based SIGINT systems such as the QUICKFIX helicopter mounted system solve this problem. The use of an aerial platform provides both the increased altitude to extend the radio line-of-sight of the system and the increased mobility needed to remain in position to support highly mobile combat operations. However, the increased enemy air defense threat of the last years has rendered these systems vulnerable if they climb too high or approach too close to the front line. This factor severely limits the effective range of their collection effort.

Airborne SIGINT collectors possess an even greater advantage over their ground-based equivalents. Positioned away from the effects of ground clutter and many of the unwanted radio signal reflections inherent in multi-path radio reception, airborne sensors are inherently more

accurate than ground-based direction finding equipment. This principle has been proven with the airborne direction finding equipment in use today. Many airborne systems are capable of delivering target locations accurate enough for direct targeting by indirect fire weapons systems. Few ground-based systems can perform this critical task.

UAVs as Intelligence Collectors

The use of UAVs in the intelligence collection role overcomes many of the limitations addressed above. The key limiting factor of most collection systems is lack of line of sight to the target area. Being aerial systems, UAVs do not suffer this limitation. Unlike manned aircraft, UAVs can operate across the FLOT, and survive, to obtain line of sight to the target area.

Due to its small size and reduced signature, a UAV is significantly harder to acquire and shoot down than manned aircraft. This factor, when combined with the fact UAVs are by definition unmanned, significantly lowers the risk involved in penetrating enemy territory and collecting intelligence information.

The ability of UAVs to operate across the FLOT over enemy territory and survive at high altitudes provides the ability to see deep into the rear areas of the enemy. Enemy units can be located, identified, and targeted at greater

ranges than previously possible. Enemy follow-on forces can thus be identified and attacked before they have a chance to influence the close battle. UAVs provide depth in planning and executing operations.

UAVs, by virtue of being air vehicles, are highly mobile and able to keep pace with the fastest moving battles. The ability to rapidly redirect assets from one area of the battlefield to another supports the AirLand Battle tenet of agility. This ability has long been recognized as a strength of aircraft, as demonstrated by the QUICKFIX system. The UAV provides this capability with the added benefit of being able to survive deep in enemy controlled territory.

The increased survivability of UAVs and the low risk of operations considered too risky for manned flights allows the UAV to loiter in the target area and conduct surveillance of a target area over time as opposed to the one-time reconnaissance of a target with manned aircraft.

The relatively low cost and ease of operation allow UAVs to be placed in units as low as battalion level. When combined with the real-time reporting of intelligence to the ground control station, UAVs are extremely responsive to the tactical maneuver commander. The ability of the UAV to provide real-time intelligence from anywhere on the battlefield will give the friendly commander the tool he

needs to act with initiative, agility, depth, and synchronization.

Validity of Army Requirements

As has been shown, UAVs are uniquely suited to correct many of the identified IEW mission area shortfalls. This section will present the findings determining if stated Army UAV requirements are valid. The Army needs valid requirements to field a UAV without the limitations of current systems. A system developed to meet invalid requirements may pass all operational testing but still fail to perform when put to the ultimate test of combat operations.

The United States Army has expressed its UAV requirements in two documents. These are the Required Operational Capability (ROC) documents for the Army developed UAV-Close and UAV-Deep categories of unmanned aerial vehicle. The Army determined that no one UAV system could be designed to perform all the diverse missions required of the UAV without severe design tradeoffs. The result is two categories of UAV making up the Army's family of non-lethal UAVs.

UAV-Close is designed to meet the UAV needs of supporting close operations. Close operations are defined as actions taken against enemy forces in contact with

friendly forces. Close operations support the current fight.[13] Close operations for the division and corps usually encompass an area approximately 30 - 50 kms beyond the front line of troops (FLOT). The FLOT is the line delineating foremost positions of friendly forces on the ground. "Close operations bear the ultimate burden of victory or defeat. The measure of success of deep and rear operations is their eventual impact on close operations."[14]

UAV-Deep is designed to support deep operations.

> Deep operations...comprise activities directed against enemy forces not in contact designed to influence the conditions in which future close operations will be conducted...successful deep operations create the conditions for future victory.[15]

Activities typical of deep operations are surveillance and target acquisition, interdiction, and command, control, and communications countermeasures (C3CM).[16] The UAV-Deep equipped with interchangeable modular payloads is designed to conduct these types of missions.

As already addressed, the most pressing of the Army's tactical intelligence collection deficiencies is its inability to collect real-time or near-real-time imagery in support of close and deep operations. UAVs offer a solution to this critical shortfall. UAVs also offer many significant improvements over the ground based SIGINT systems currently employed.

The Joint UAV Program

The Joint UAV Master Plan proscribes the development of four categories of UAV in the Department of Defense non-lethal family of unmanned vehicles. These are the joint close-range (JUAV-CR), short-range (JUAV-SR), medium-range (JUAV-MR), and the endurance (JUAV-E) categories of UAV. These categories refer to the characteristics of the air vehicle in terms of operational range and duration of flight.[17] The basic capabilities of these categories are illustrated in Figure 2.

One of the goals of the joint UAV program is to achieve maximum interoperability among the different UAV categories.[18] An example of this is the ability of a common ground control station to control both the JUAV-CR and JUAV-SR. This goal is expected to reduce development and operating costs. The joint short-range (JUAV-SR) has been chosen as the first category of UAV to be developed and procured. It will serve as the baseline to establish the interoperability and commonality goals for the remaining systems.[19]

The requirements for the JUAV-SR category are clearly defined and stated in the Joint Unmanned Aerial Vehicle Short Range (JUAV-SR) System Specification. The requirements for the joint close-range (JUAV-CR) category will be derived from experience with the short-range

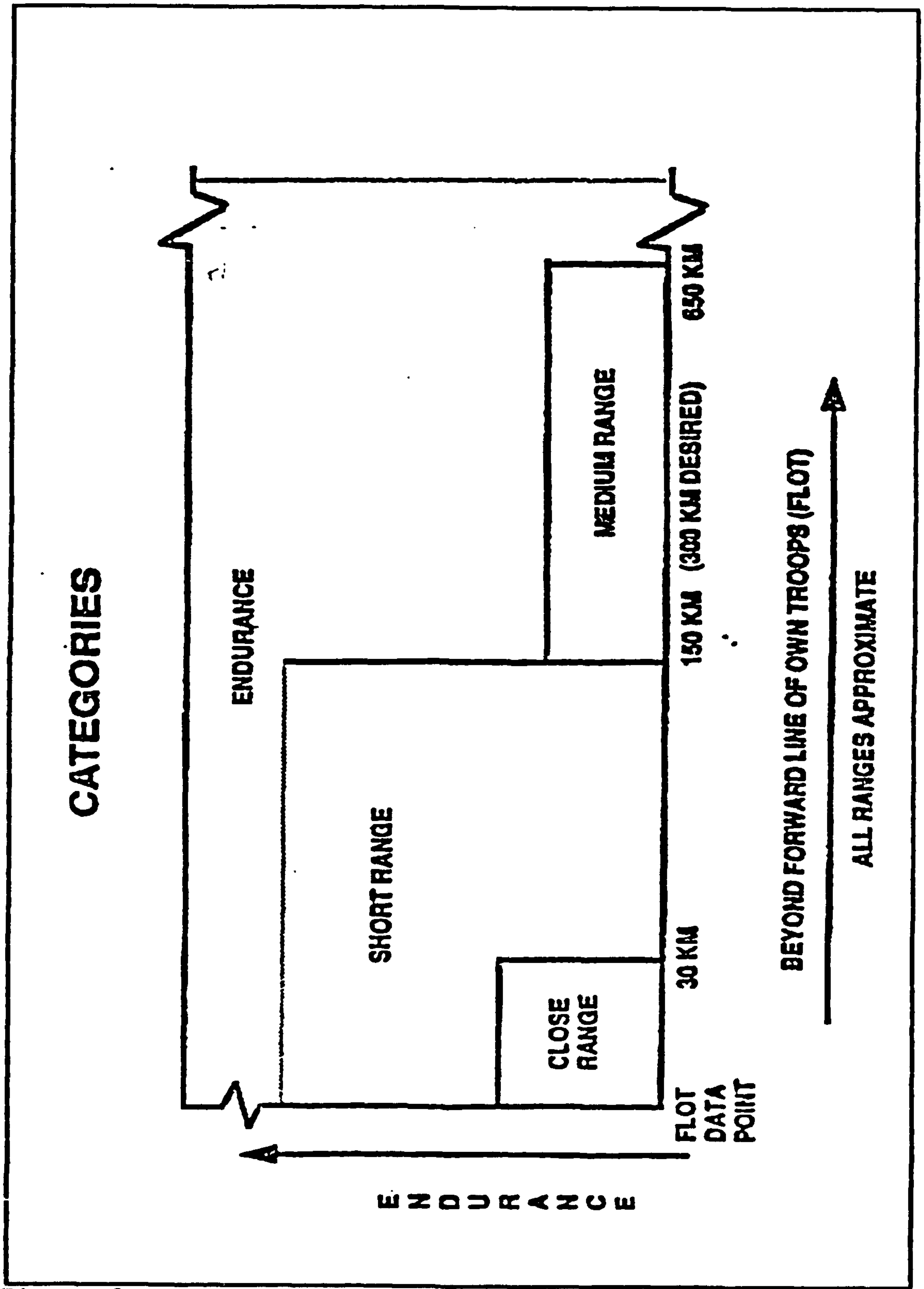

Figure 2 - Joint UAV Categories.

systems, past developmental efforts within the services, and experience developed from experimentation with foreign and very low cost systems.[20] Current requirements for the JUAV-CR system are described in the Mission Need Statement - Joint UAV Close-Range and the System Concept Paper for Unmanned Air Vehicle - Close Range.

The JUAV-CR system concept calls for two models of UAV to satisfy the diverse mission requirements for this category of UAV. The JUAV-CR has a requirement for dry launch and recovery from a frigate size surface combatant as well as a land-based requirement. The dry recovery requirement significantly complicates the design of one system optimum for both applications. The Joint Program Office has recommended modifying an existing fixed wing design for the land role and modifying an existing rotary wing design for the sea-based role. The specifications for the land-based version of the JUAV-CR are used for the purpose of this research.

The requirements for the JUAV-CR specified in these two documents are defined in much broader and less specific terms than those stated for the Army UAV-Close system. This is a result of the Joint Program Office strategy for developing its requirements. It is difficult to determine if JUAV-CR will meet Army needs because the joint requirements lack specificity.

It is possible to evaluate the JUAV-CR requirements only so far as the specifications allow. However, even at this level of definition, differences between the UAV-Close and the JUAV-CR are evident. These differences are identified in Chapter Five.

Summary

The UAV requirements as specified for the Army UAV-Close and UAV-Deep are determined to be valid to support tactical combat operations of the United States Army.

The Army UAV program, off to a slow start with the AQUILA program, ended up generating a very thorough and comprehensive set of requirements. Learning from the AQUILA experience, and exploring new possibilities as they were suggested, the ROCs for the finalized UAV-Close and UAV-Deep programs are extremely well stated, justified, and proven, through off the shelf purchases, engineering prototypes, demonstrations, and operational deployments.

CHAPTER FOUR

ENDNOTES

[1]Department of the Army, Operations, Field Manual (FM 100-5) (Washington, D.C.: United States Government Printing Office, 5 May 1986), 15.

[2]Ibid.

[3]Ibid., 16.

[4]Ibid., 16-17.

[5]Ibid., 17.

[6]Department of the Army, Intelligence and Electronic Warfare Operations, Field Manual (FM 34-1) (Washington, D.C.: United States Government Printing Office, 31 March 1984), 3-28.

[7]Ibid., 3-28.

[8]Ibid., 3-30.

[9]Ibid., 3-30 - 3-31.

[10]Ibid., 3-33.

[11]Ibid.

[12]Ibid., 3-34.

[13]Operations, FM 100-5, 19.

[14]Ibid.

[15]Ibid.

[16]Ibid., 20.

[17]UAV Joint Program Office, Unmanned Aerial Vehicle Master Plan - 1990 Update, (Department of Defense, Washington, D.C., 26 January 1990), 6.

[18]UAV Master Plan - 1990 Update, 6.

[19]Ibid., 1.

[20]Ibid.

CHAPTER FIVE

JOINT UAV PROGRAM VERSUS ARMY NEEDS

Introduction

This chapter compares Army UAV requirements to those of the joint UAV program. It is organized into four sections. The first section is the introduction, stating the purpose and organization of the chapter. Section two compares the requirements for the Army UAV-Deep against the specifications for the JUAV-SR, operating as the Army UAV-Deep. The JUAV-CR operating as the Army UAV-Close is examined in the last section.

JUAV-SR as the Army UAV-Deep

This section examines the JUAV-SR system in the role of the Army UAV-Deep. The findings compare Army UAV-Deep requirements against the specifications of the JUAV-SR category. Preliminary research shows the two systems are very similar, JUAV-SR specifications rely heavily on the Army UAV-Deep requirements.

The comparison is conducted by major sub-components of the systems. These are general system characteristics, air vehicle (AV), mission payload (MP), data link (DL), ground control station (GCS), video monitor (VM), and launch and recovery section (LRS). All specified criteria for each sub-system is addressed. A summary of the comparison is provided in a table for each of the sub-systems.

The source document for all requirements for the Army UAV-Deep system is the Required Operational Capability Statement for the Deep Unmanned Aerial Vehicle (Deep UAV), 16 August 1988. The Joint Unmanned Aerial Vehicle Short Range (JUAV-SR) System Specification (Draft), 25 October 1988, provides the specifications for the JUAV-SR used in this section.

GENERAL SYSTEM CHARACTERISTICS.

Reliability. The required level of system reliability is classified. Specified reliability figures for the JUAV-SR equal or exceed Army requirements.

Weather. The Army requires the UAV-Deep to operate in weather conditions consisting of light icing, heavy fog, and minimum visibility of two kilometers. These required conditions allow the UAV to operate when other aerial systems are grounded. Specifications for the JUAV-SR satisfy all Army requirements.

Table 1 - Army Deep, General System Characteristics.

Criterion	Army	Joint
Reliability	Classified	Equals
Weather	All weather	Equals
Transportability	100% using organic vehicles. Sea and rail transportable. Air transportable with medium lift helicopters and C-130.	Equals
Mobility	Same as supported unit.	Equals
Responsiveness	Classified.	Equals
Electrical power	110v/60hz and 220v50hz.	Equals
Communications	Standard tactical comms	Equals
Survivability	Same as supported force.	N/A
NBC	Standard decon procedures. Operable and sustainable while wearing complete chemical protective equipment.	Equals
System control	Control of the air vehicle can be exchanged between the ground control station and the launch/recovery section.	Equals

Transportability. The Army requires the entire UAV unit be 100% transportable using organic vehicles. All vehicles and containers are to be transportable by standard sea and rail modes. All components are to be air transportable by medium lift helicopters and C-130 aircraft.

The ability to conduct air transport without the need of disassembling components is desired. Joint specifications fully support these requirements.

Mobility. The ground components of the system are to possess cross-country mobility equal to that of the support vehicles of the supported unit. The use of standard inventory vehicles is required. JUAV-SR specifications fully support mobility requirements.

Responsiveness. The required ability of the UAV-Deep to respond within specified times to mission tasking is classified. Response time for the JUAV-SR satisfies the Army requirement.

Electrical power. The ability to power the system from world standard 110 volt/60 hertz and 220 volt/50 hertz commercial power is required. Joint requirements satisfy this need.

Communications. The UAV-Deep is required to use standard Army tactical communications systems to communicate both within the UAV unit and with supported units. JUAV-SR meets this requirement by specifying the use of currently fielded communication equipment as government furnished equipment (GFE) for the purpose of communicating with supported units, support of command and control, and report dissemination.

Survivability. Survivability of the ground components of the UAV-Deep system against direct and

indirect fire attack is specified to equal that for systems of the supported force. JUAV-SR specifications only state the air vehicle be survivable in a medium intensity conflict.

Operations in a nuclear, biological, and chemical (NBC) environment. The Army requires the UAV-Deep system to be fully operational after undergoing standard decontamination procedures following a chemical attack. The system is also required to be fully operational and sustainable while personnel are wearing complete chemical protective mask and clothing. Specifications for the JUAV-SR fully support this requirement.

System control. The Army specifies control of the air vehicle be capable of being passed from the launch and recovery section to the ground control station and vice-versa. The JUAV-SR system specifications support this requirement.

AIR VEHICLE (AV).

Flight endurance. Flight endurance specifications for both the UAV-Deep and JUAV-SR systems are classified. However, the specified flight endurance time for the initial JUAV-SR system satisfies the Army's required endurance times. This may be achieved using more than one air vehicle to provide continuous operations. The Army's desired flight endurance goal will not be met with the initial JUAV-SR

system. The JUAV-SR is assessed to equal or exceed the endurance requirement of the UAV-Deep.

Navigation accuracy. The required accuracy of navigation for the UAV-Deep is classified. Navigation accuracy of the JUAV-SR is also classified, but equals or exceeds Army requirements.

Rate of climb. Rate of climb for the Army system is 500 feet per minute on a standard hot day, with 1000 feet per minute desired. JUAV-SR specifications equal or exceed this requirement.

Service ceiling. 10,000 feet above mean sea level (MSL) is required of the Army system, 12,000 feet MSL is desired. JUAV-SR specifies a maximum altitude is classified, but fully supports the Army requirement.

Navigation. The UAV-Deep requires autonomous navigation of the air vehicle between selected waypoints programmed into the air vehicle prior to take-off. The ability to update the waypoints while the air vehicle is in flight is also specified. The Army also specifies the ability of the air vehicle to execute an automatic loiter in a target area upon command from the ground control station. The capability of the air vehicle to execute preprogrammed lost link procedures in the event of loss of control signal is also required. The air vehicle must be capable of conducting an automatic return to a predetermined recovery area if the control link is seriously interrupted.

Table 2 - Army Deep, Air Vehicle.

Criterion	Army	Joint
Flight endurance	Classified	Exceeds
Navigation accuracy	Classified	Exceeds
Rate of Climb	500 fpm required 1000 fpm desired	Exceeds
Service Ceiling	10,000 ft mean sea level	Equals
Navigation	Fully autonomous between selectable waypoints. In-flight updates. Auto loiter on command. Lost link procedures. Auto return to recovery.	Equals
Displays	Must display heading reference magnetic north and self location in UTM grid coordinates.	Equals
Carrying capacity	Modular payloads	Equals
Coverage	Survive in intense air defense and EW environment.	Equals

Specifications for JUAV-SR fully support all navigation and preprogrammed flight operations of the Army UAV-Deep.

Displays. The air vehicle must be capable of determining its heading reference to magnetic north and locating itself using UTM grid coordinates. This data must be passed through the data link to the air vehicle operator in the ground control station, launch/recovery section, and video monitor. The JUAV-SR satisfies this requirement.

Payload capacity. The Army desires a variety of modular interchangeable mission payload capability. The specifications for the JUAV-SR support this concept by specifying the installation of all sensor equipment in modular mission payloads (MMP).

Coverage. The air vehicle must be capable of providing target coverage in an intense air defense and electronic warfare environment. Specifications for the JUAV-SR are the same.

MISSION PAYLOAD (MP).

Required capability. UAV-Deep requires a day/night imagery sensor providing real-time imagery to the ground station. The JUAV-SR system requires the additional capability of a SIGINT sensor, and a data relay payload. The data relay modular mission payload will allow a relay configured air vehicle to serve as an airborne relay to extend the range of a sensor equipped air vehicle.

Resolution. The Army requires sensor resolution sufficient to recognize light tactical vehicles from the operating altitude. Resolution of the JUAV-SR is classified, but Army requirements are met or exceeded.

Fields of view. UAV-Deep specifies the imagery payload possess a minimum of two fixed fields of view (FOV). A continuous zoom capability is desired. A wide FOV is required to conduct terrain recognition and search/detection

Table 3 - Army Deep, Mission Payload.

Criterion	Army	Joint
Capability	Day/night imagery	Exceeds
Resolution	Sufficient to recognize light tactical vehicles from operational altitudes.	Equals
Fields of View	Two fields of view. Wide FOV for terrain recognition and search/detection of vehicles. Narrow FOV to permit recognition of light tactical vehicles.	Equals
Tgt location accuracy	Classified	Equals
Desired payloads	Communications relay. SIGINT package. Others.	Less

of light tactical vehicles and larger equipment. The narrow FOV will allow the operator to recognize light tactical vehicles. The JUAV-SR field of view requirements are classified. They satisfy the needs of the Army.

Target location accuracy. The target location accuracy of the UAV-Deep is classified, however, the targeting requirements of new generation long range weapons systems are satisfied at the maximum operating range of the system. Target location accuracy of the JUAV-SR is also classified, but Army requirements are satisfied.

Desired payloads. In addition to the required day/night imagery payload, the Army desires the following

payload capabilities; communications relays, forward air defense sensors, mine field detection sensors, and target designation capabilities. The joint program envisions an additional data relay payload to extend the range of JUAV-SR operations.

DATA LINK (DL).

Radius of operation. UAV-Deep specifies a data link radius of operation of 150 km (300 km desired). The specified JUAV-SR radius of action for the data link is 200 km. The use of relay aircraft to achieve this range is permitted.

Electromagnetic environment. The Army specifies the ability of the data link to operate in a highly cluttered electromagnetic spectrum. This includes NATO and commercial/urban noise environments. The use of low probability of intercept (LPI) technology for the data link is desired. JUAV-SR specifications support these requirements including the use of LPI technology as a growth goal.

Frequency. UAV-Deep requires the data link be capable of simultaneous transmission and reception of the command uplink and the sensor data/air vehicle telemetry downlink using discrete, selectable frequencies. Army needs for frequency use are fully supported in the JUAV-SR specifications.

Table 4 - Army Deep, Data Link.

Criterion	Army	Joint
Radius of operation	150 km	Exceeds
Environment	Operable in cluttered electromagnetic spectrum to include NATO and commercial/urban noise environment.	Equals
Frequency	Uses selectable frequencies.	Equals
Interoperability	Can downlink to GSM when within range.	Less

Interoperability. The ability of UAV-Deep to downlink imagery to the JSTARS ground station module (GSM) when within range is desired. The JUAV-SR addresses this desire by requiring the mission payload and control station (ground station equivalent) to provide the necessary data interfaces to the JSTARS GSM for imagery products and the GUARDRAIL ground processing facility (GPF) for COMINT data.

GROUND CONTROL STATION (GCS).

Shelters. The Army specifies the use of standard vehicles and equipment shelters to carry and house UAV system components. Specifications for the JUAV-SR support this requirement.

Table 5 - Army Deep, Ground Control Station.

Criterion	Army	Joint
Shelter	Standard shelters	Equals
Data displays	Sufficient to control air vehicle and mission payload for all functions.	Equals
Mission planning	Automated capability	Equals
Control of mission payload	Must control sensor azimuth, depression angle, and FOV.	Equals
Control of air vehicle	Must be able to program and reprogram air vehicle in flight.	Equals
Data processing	Must receive and store imagery continuously for 3 hours. During receipt must be able to freeze and save selected segments of imagery into a buffer for later analysis. Removable storage medium.	Equals
Recovery of air vehicle	Capable of recovering air vehicle if launch/recovery section is disabled.	N/A
Environmental control	Sufficient for crew to conduct continuous operations.	Equals

Data displays. UAV-Deep specifies the ground control station be capable of displaying all control information required to control and reprogram the air vehicle in flight, and control the mission payload. Display

of target locations in UTM coordinates on demand is required. JUAV-SR specifications fully support these requirements.

Mission planning. An automated mission planning capability is required. This includes the ability to display data necessary for mission execution, search of areas, targeting, and determining mission payload status. JUAV-SR requires the mission planning and control station (MPCS) to automate mission planning aids.

Control of mission payload. The Army requires the payload operator be capable of controlling mission payload azimuth, depression angle, and field of view. JUAV-SR fully supports this requirement.

Control of air vehicle. The air vehicle operator must be able to program and reprogram the air vehicle during flight and be capable of conducting real-time flight operations. The JUAV-SR specifies equivalent requirements.

Data processing. The UAV-Deep specifies the ground control station be capable of receiving and storing three hours of continuous imagery. During receipt of imagery the capability must exist to freeze and save selected segments of imagery into a buffer for later recall and analysis. The storage media must be removable. The system specifications for the JUAV-SR meet or exceed all data processing requirements of UAV-Deep.

Table 6 - Army Deep, Video Monitor.

Criterion	Army	Joint
Operators	One operator with minimum training.	N/A
Portability	Transportable by no more than two soldiers.	N/A
Capability	Receive real-time down-linked imagery direct from air vehicle or relay.	N/A
Data processing	Must receive and store imagery continuously for 3 hours. During receipt must be able to freeze and save selected imagery into a buffer for later analysis. Removable storage medium.	N/A
Operate on move	The ability of the video monitor to receive and display imagery while on the move is desired.	N/A

Recovery of air vehicle. UAV-Deep specifies the ability of the ground control station to recover an air vehicle if the launch/recovery section is disabled. The ability of the MPCS to recover the air vehicle is not addressed for the JUAV-SR.

Environmental control. The Army requires the ground control station be environmentally controlled for the crew

to permit continuous operations. Joint requirements specify the same level of environmental control.

VIDEO MONITOR.

The UAV-Deep specifies a remote video monitor capability. It must be capable of operation by one soldier with minimum training. It must be transportable by no more than two soldiers. The video monitor must be capable of recording, playback, and freezing imagery. The downlinked video must be received direct from the air vehicle or relay. The JUAV-SR specifications fully support this requirement.

LAUNCH AND RECOVERY SECTION (LRS).

Mission planning. The Army UAV-Deep requirements state the need for the launch recovery section to be capable of conducting complete mission planning. This specifies the ability to program the air vehicle during pre-flight and in-flight operations with navigation waypoints. The JUAV-SR meets this requirement.

Handoff of control. The UAV-Deep requires the launch and recovery section be capable of exchanging control of in-flight air vehicles with the ground control station. JUAV-SR fully satisfies this requirement.

Continuous operations. In order to conduct continuous operations over the target area with air vehicles of less flight endurance than desired, the UAV-Deep requires

Table 7 - Army Deep, Launch and Recovery Section.

Criterion	Army	Joint
Mission planning	Capable of programming air vehicle prior to flight and reprogramming while in flight.	Equals
Control hand-off	Launch/recovery section can receive handoff from and handoff to ground control station control of the air vehicle.	Equals
Continuous operations	Be capable of launching, controlling, and recovering multiple air vehicles to support continuous operations.	Equals
Communications	Capable of maintaining communications with all ground control stations and launch/recovery sections assigned to UAV unit.	Equals

the launch and recovery section to be capable of launching, recovering, and controlling multiple air vehicles. The JUAV-SR specifications satisfy this requirement.

Communications. UAV-Deep requires any launch and recovery section to maintain communications with all ground control stations and other launch and recovery sections assigned to the UAV unit. The joint program supports this requirement.

JUAV-CR as the Army UAV-Close

This section examines how the joint close-range UAV (JUAV-CR) will meet the needs of the Army if fielded as the Army UAV-Close. The Army UAV-Close requirements were developed to provide timely and accurate intelligence support to the commander conducting close operations. These findings are a result of comparing the Army UAV-Close requirements with the specifications established for the JUAV-CR.

As with the discussion of deep operations in the preceding section, the comparison is conducted by major sub-components of the system. These are the; general system characteristics, air vehicle (AV), mission payload (MP), data link (DL), ground control station (GCS), video monitor (VM), and launch and recovery section (LRS). All specified criteria for each sub-system is addressed. A summary of the comparison is provided in a table for each of the sub-systems.

The source document for all requirements for the Army UAV-Close system is the Required Operational Capability Statement for the Close Unmanned Aerial Vehicle (Close UAV), 16 August 1988. The System Concept Paper for Close Range - Unmanned Aerial Vehicle (CR-UAV), 28 July 1989, provides the data for the JUAV-CR used in this section.

GENERAL SYSTEM CHARACTERISTICS.

Reliability. The required level of system reliability is classified. Specified reliability figures for the JUAV-CR equal or exceed the Army requirements.

Coverage. The coverage time provided by the UAV-Close within a 36 hour period is also a classified requirement. The JUAV-CR exceeds the required Army figures.

Weather. The Army requires the UAV-Close to operate in weather conditions consisting of light icing, heavy fog, and minimum visibility of two kilometers. These required conditions allow the UAV to operate when other aerial systems are grounded. No weather requirements are yet stated for the JUAV-CR.

Transportability. The Army requires the entire UAV unit be 100% transportable using organic vehicles. All vehicles and sub-systems are to be transportable by standard sea, air, and rail modes. All components are to be air transportable by medium lift helicopters and C-130 aircraft. The ability to conduct air transport without the need of disassembling components is desired. Joint requirements do not address transportability.

Mobility. The UAV-Close is to possess cross-country mobility equal to that of the support vehicles of the supported unit. Mobility requirements are not addressed in the JUAV-CR program.

Table 8 - Army Close, General System Characteristics.

Criterion	Army	Joint
Reliability	Classified.	Equals
Weather	All weather.	N/A
Transportability	100% using organic vehicles. Sea and rail transportable. Air transportable using medium lift helicopters and C130.	N/A
Ground mobility	Same as supported unit.	N/A
Responsiveness	Classified.	N/A
Electrical power	110v/60hz and 220v/50hz.	N/A
Communications	Standard tactical comms.	N/A
Survivability	Same as supported force.	N/A
NBC	Standard decon procedures. Operable and sustainable while wearing complete chemical protective equipment.	N/A
System control	Ground control station and launch recovery section can handoff control of air vehicle to each other.	N/A

Responsiveness. The required ability of the UAV-Close to respond within specified times to mission tasking is classified. Response time is not specified for the JUAV-CR.

Electrical power. The ability to power the UAV-Close system from world standard 110 volt / 60 hertz and 220 volt / 50 hertz commercial power is required. Joint requirements do not specify electrical power requirements for the JUAV-CR.

Communications. The UAV-Close is required to use standard Army tactical communications systems to communicate both within the UAV unit and with the supported units. JUAV-CR has no stated equivalent requirement.

Survivability. Survivability of the Army system is specified to equal the hardening against directed energy weapons and electronic warfare measures comparable to that provided for systems of the supported force. Equivalent requirements for the JUAV-CR are not specified.

Operations in a nuclear, biological, and chemical (NBC) environment. The Army requires the UAV-Close system to be fully operational after undergoing standard decontamination procedures following a chemical attack. The system is also required to be fully operational and sustainable in a MOPP IV environment. This means fully operational with the crew wearing complete chemical protective clothing and equipment. No equivalent requirement for the JUAV-CR exists.

System control. The Army specifies the ground control station be capable of conducting handoff of air vehicle control to, and receiving handoff from, the launch

and recovery section. The JUAV-CR system concept does not envision a launch/recovery section separate from the ground control station. Therefore, this requirement is not addressed in the joint concept.

AIR VEHICLE (AV).

Flight endurance. System endurance for the UAV-Close is specified at three hours. This may be achieved using more than one air vehicle, such as two vehicles each providing target coverage for one and a half hours. The JUAV-CR system concept specifies endurance of one to six hours for an individual air vehicle. The JUAV-CR is assessed as a possible shortfall in this requirement.

Navigation accuracy. Required navigation accuracy for the UAV-Close is 100 meters or less circular error of probability (CEP) in the horizontal plane and 200 feet or less error vertical distance. Navigation accuracy for the joint system is not specified.

Rate of climb. Rate of climb for the Army system is 500 feet per minute on a standard hot day, with 1000 feet per minute desired. No rate of climb is specified for the JUAV-CR.

Service ceiling. 10,000 feet above mean sea level (MSL) is required of the Army system, 12,000 feet MSL is desired. The system concept paper for the JUAV-CR specifies a maximum altitude of 10,000 feet MSL.

Table 9 - Army Close, Air Vehicle.

Criterion	Army	Joint
Flight endurance	Three hours.	Less
Navigation accuracy	100 meters horizontal CEP. 200 feet vertical CEP.	N/A
Rate of Climb	500 feet per minute. 100 fpm desired.	N/A
Altitude	10,000 ft MSL. 12,000 ft MSL desired.	Equals
Navigation	Autonomous between selected waypoints. In-flight updates. Auto-loiter on command. Lost link procedures. Automatic return to recovery area.	Less
Displays	Air vehicle must display; magnetic heading and self location in UTM grid. Display all air vehicle telemetry to operator in LRS or GCS.	N/A
Carrying capacity	50 pound payload. Variety of modular interchangeable mission payloads is desired.	Less

Navigation. The UAV-Close requires autonomous navigation of the air vehicle between selectable waypoints programmed into the air vehicle prior to take-off. The ability to update the waypoints while the air vehicle is in flight is also specified. The Army also specifies the ability of the air vehicle to execute an automatic loiter in

a target area upon command from the ground control station. The capability of the air vehicle to execute preprogrammed lost link procedures in the event of loss of control signal is also required. The air vehicle must be capable of conducting an automatic return to a predetermined recovery area if the control link is seriously interrupted. The system concept for the JUAV-CR does not envision autonomous flight operations for the air vehicle.

Displays. The air vehicle must be capable of determining its heading reference to magnetic north and locating itself using UTM grid coordinates. This data must be passed through the data link to the air vehicle operator in the ground control station, launch/recovery section, and video monitor. The specifications for JUAV-CR do not address this operational characteristic.

Payload carrying capacity. The Army desires the UAV-Close to be capable of carrying a variety of modular interchangeable mission payloads. This capability is envisioned in the JUAV-CR system concept but is not yet specified as a requirement. Payloads for the JUAV-CR are currently specified to be 50 pounds or less.

MISSION PAYLOAD (MP).

Required capability. UAV-Close states a requirement for a day/night imagery sensor providing real-time imagery to the ground station. The JUAV-CR system concept requires

Table 10 - Army Close, Mission Payload.

Criterion	Army	Joint
Capability	Real-time day/night passive imagery.	Exceeds
Resolution	Sufficient to recognize light tactical vehicles from operational altitudes.	N/A
Fields of View	Two fields of view. Wide FOV for terrain recognition and search/detection of vehicles. Narrow FOV to permit recognition of light tactical vehicles.	N/A
Tgt location accuracy	100m CEP at maximum operating range.	N/A
Desired payloads	Communications relay. SIGINT package. Others.	Equals

the same.

Resolution. The Army requires sensor resolution sufficient to recognize light tactical vehicles from the operating altitude. The joint concept does not address resolution.

Fields of view. UAV-Close specifies the imagery payload possess a minimum of two fixed fields of view (FOV). A continuous zoom capability is desired. A wide FOV is required to conduct terrain recognition and search/detection of light tactical vehicles and larger equipment. The narrow

FOV will allow the operator to recognize light tactical vehicles. The JUAV-CR does not specify field of view.

Target location accuracy. The Army requires the ability to locate detected targets to within 100 meters CEP at the maximum operating range of the system. JUAV-CR does not state a required target location accuracy.

Desired payloads. In addition to the required day/night imagery payload, the Army desires the following payload capabilities; communications relays, forward air defense sensors, mine field detection sensors, and target designation capabilities. The joint program also envisions additional payload capabilities, if restricted to fifty pounds or less.

DATA LINK (DL).

Radius of operation. UAV-Close specifies a data link radius of operation of 50 km. The specified JUAV-CR radius of action is 40 miles, exceeding the needs of the Army.

Electromagnetic environment. The Army specifies the ability of the data link to operate in a highly cluttered electromagnetic spectrum. This includes both NATO and commercial/urban noise environments. The use of low probability of intercept (LPI) technology for the data link is desired. JUAV-CR does not address data link requirements.

Table 11 - Army Close, Data Link.

Criterion	Army	Joint
Radius of operation	Classified	Exceeds
Environment	Operable in cluttered electromagnetic spectrum to include NATO and commercial/urban noise environment.	N/A
Frequency	Uses selectable frequencies.	N/A
Interoperability	Can downlink to GSM when within range.	N/A

Frequency. UAV-Close requires the data link be capable of simultaneous transmission and reception of the command uplink and the sensor data/air vehicle telemetry downlink using discrete, selectable frequencies. Frequency use is not addressed for the JUAV-CR.

Interoperability. The Army desires the UAV-Close be capable of using the UAV-Deep system as a relay to extend the range of the Close system. The ability of the air vehicle to downlink imagery to the JSTARS Ground Station Module (GSM) when within range is also desired. The JUAV-CR concept does not address either capability.

GROUND CONTROL STATION (GCS).

Shelters. The Army specifies the use of standard vehicles and equipment shelters to carry and house UAV

Table 12 - Army Close, Ground Control Station.

Army Requirement	Joint Specification	
Shelter	Standard shelters.	Exceeds
Data displays	Sufficient to control air vehicle and mission payload for all functions.	N/A
Mission planning	Automated capability.	N/A
Control of mission payload	Must control sensor azimuth, depression angle, and FOV.	N/A
Control of air vehicle	Must be able to program and reprogram air vehicle in flight.	Less
Data processing	Must receive and store imagery continuously for 3 hours. During receipt must be able to freeze and save selected segments of imagery into a buffer for later analysis. Removable storage medium.	N/A
Recovery of air vehicle	Capable of recovering air vehicle if launch/recovery section is disabled.	N/A
Environmental control	Sufficient for crew to conduct continuous operations.	N/A

system components. This area is not addressed in the joint concept for JUAV-CR.

Data displays. The Army specifies the ground control station be capable of displaying all control information required to control and reprogram the air vehicle in flight,

and control the mission payload. Display of target locations in UTM coordinates on demand is required. The system concept for JUAV-CR does not address display of data.

Mission planning. An automated mission planning capability is required. This includes the ability to display data necessary for mission execution, search of areas, targeting, and determining mission payload status. Mission planning capabilities are not addressed in the JUAV-CR concept.

Control of mission payload. The Army requires the payload operator be capable of controlling mission payload azimuth, depression angle, and field of view. JUAV-CR does not address mission payload control.

Control of air vehicle. The air vehicle operator must be able to program and reprogram the air vehicle during flight and be capable of conducting real-time flight operations. The joint concept envisions all JUAV-CR flight operations being conducted by the operator. Autonomous air vehicle operations are not addressed.

Data processing. The UAV-Close requires the ground control station be capable of receiving and storing three hours of continuous imagery. During receipt of imagery the capability must exist to freeze and save selected segments of imagery into a buffer for later recall and analysis. The storage media must be removable. The system concept for the JUAV-CR does not address data processing requirements.

Recovery of air vehicle. UAV-Close specifies the ability of the ground control station to recover an air vehicle if the launch/recovery section is disabled. As the JUAV-CR does not envision a separate launch/recovery section, this requirement is not addressed.

Environmental control. The Army requires the ground control station be environmentally controlled for the crew to permit continuous operations. The joint concept does not address environmental control.

VIDEO MONITOR (VM).

The JUAV-CR system does not address a remote video monitor capability. Therefore, none of the requirements of the Army for this sub-component are met.

Operators. The UAV-Close requires the video monitor be operable by one soldier with minimum additional training. It is desired no additional training be required. JUAV-CR specifies a two man crew for the entire UAV system and does not address remote video monitor capability.

Transportability. The Army requires the video monitor be transportable by no more than two soldiers.

Capability. The video monitor is to be capable of receiving and displaying real-time imagery direct from the air vehicle data link.

Data processing. UAV-Close specifies the video monitor perform the same data processing actions required of

Table 13 - Army Close, Video Monitor.

Criterion	Army	Joint
Operators	One operator with minimum training.	N/A
Portability	Transportable by no more than two soldiers.	N/A
Capability	Receive real-time down-linked imagery direct from air vehicle or relay.	N/A
Data processing	Must receive and store imagery continuously for 3 hours. During receipt must be able to freeze and save selected imagery into a buffer for later analysis. Removable storage medium.	N/A
Operate on move	The ability of the video monitor to receive and display imagery while on the move is desired.	N/A

the ground control station. These capabilities are addressed in the ground control station sub-system.

Movement. The capability of the video monitor to receive imagery while on the move is desired.

LAUNCH AND RECOVERY SECTION (LRS).

The system concept for the JUAV-CR envisions a very light system. The concept addresses a small UAV unit not requiring a separate launch and recovery section. All such

Table 14 - Army Close, Launch and Recovery.

Criterion	Army	Joint
Mission planning	Capable of programming air vehicle prior to flight and reprogramming while in flight.	N/A
Independent operation	Able to function as ground control station for independent, stand alone operations.	N/A
Launch area	No more than 1000 ft clear strip.	Exceeds
Recovery area	No more than 1000 ft clear strip.	Exceeds
Continuity of operations	Launch and recovery operations do not interfere with each other.	N/A
Control hand-off	Launch/recovery section and ground control station can exchange control of air vehicles.	N/A

operations are conducted by the mission planning and control station. It follows that none of the UAV-Close requirements are addressed in the JUAV-CR system concept.

Mission planning. The Army requires a completely automated mission planning capability be available in the launch/recovery section. This includes the capability to program the air vehicle prior to launch and the ability to reprogram in flight.

Independent operations. The launch/recovery section must perform the functions of the ground control station. This permits the launch/recovery section to operate as a stand alone system with the air vehicle for independent or contingency operations.

Launch and recovery. UAV-Short launch operations require clearance of a 150 ft obstacle at a maximum of 1000 ft from the launch site. Recovery operations are required to be accomplished on a clear strip less than 1000 feet in length. JUAV-CR far exceeds these requirements by specifying both launch and recovery operations be performed from a soccer size field. UAV-Close specifies recovery operations will not interfere with launch operations. JUAV-CR does not address this issue.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the research conclusions and recommendations for change to the joint UAV program. Recommended research topics for continued study are also provided. The conclusions demonstrate the primary research question has been answered - the joint UAV program satisfies the UAV requirements of the Army.

Following the introduction, the chapter starts with a summary of the significant findings developed from Chapter Five. The research conclusions follow in the next section. These conclusions are logical extensions of the findings presented in chapters four and five. Following the conclusions are recommended changes to both the Army and joint UAV programs. Recommended topics for further research are then presented, followed by a summary of this study at the end of the chapter.

Summary of Significant Findings

Two distinct factors are obvious when comparing the requirements of the Army with those of the joint UAV program. The joint program specifications for the JUAV-SR are clearly stated and very similar to the requirements of the Army UAV-Deep system. At the same time, specifications for the JUAV-CR, when stated, define a system concept very different from that as developed for the UAV-Close. In many areas the JUAV-CR specifications are not well enough defined to provide a comparison with the UAV-Close.

JUAV-SR / Army UAV-Deep

The differences between the JUAV-SR and the Army UAV-Deep are few, and relatively minor. The specifications for the JUAV-SR are so similar to the UAV-Close, it is easy to believe the UAV Joint Program Office used the requirements for the UAV-Deep as the base document for the JUAV-SR system specifications. Considering the requirements for the UAV-Deep are as well defined and clearly stated as discussed in Chapter Four, this is not surprising. The notable differences in the two systems are in the areas of desired flight endurance, desired payloads, and interoperability.

Flight endurance of the JUAV-SR is adequate to meet the required flight endurance times of UAV-Deep, but do not satisfy the desired endurance times for the system. This

difference is not a serious problem due to the ability of the JUAV-SR to conduct continuous operations over the target area through the use of multiple air vehicles. The operational concept for UAV-Deep allows for multiple air vehicles to accomplish longer missions. However, the preferred solution is the use of a single, longer endurance air vehicle, if cost effective. The disadvantage of multiple air vehicles is the increased number of successful launch and recovery operations required to conduct the same mission.

The Army concept for UAV-Deep calls for additional mission payloads to be developed. These are payloads designed to conduct communications relay, forward air defense surveillance, mine field detectors, target designation, and other missions. As currently written, the only additional payloads planned for the JUAV-SR are a data relay package and a SIGINT collection payload. The data relay will allow one air vehicle to act as an airborne relay for another, greatly extending the operational range. This difference is not viewed as a major problem, future payloads may be designed and installed after the initial production is started.

The Army desires the UAV-Deep system be capable of down-linking imagery direct to the JSTARS ground station module (GSM) for use in the targeting effort. Additionally, a direct reporting interface to the automated fire direction

system is required. JUAV-SR provides for the link to the fire direction system, but does not provide for direct down-link of the imagery to the JSTARS GSM. The JUAV-SR specifies the ground control station equivalent, the mission planning and control station, be capable of providing imagery to the JSTARS GSM through hard-wired cabling. This solution requires the positioning of a UAV ground control station in the proximity of the JSTARS GSM. Although not the same approach as that specified by the Army, this solution will provide the ability for the UAV to conduct surveillance operations in conjunction with JSTARS.

JUAV-CR / Army UAV-Close

The most obvious observation to be made of the JUAV-CR requirements is the general lack of specificity when compared to the requirements for the UAV-Close. Even with many of the system characteristics not yet defined or addressed, it is obvious the joint program envisions a much smaller and lighter system than the Army designed UAV-Close. The JUAV-CR system concept as currently stated far exceeds the launch and recovery requirements and ground mobility and strategic transportability requirements of the Army. Personnel, vehicle and equipment requirements are much reduced compared to the UAV-Close concept of operation. The price paid for these improvements is a potentially reduced operational capability.

The method of flight control is a major difference between the two systems. UAV-Close requires the air vehicle employ both preprogrammed and manual flight modes. JUAV-CR specifies only a manual flight mode. In manual mode all flight commands are issued over the data link by the flight operator. A preprogrammed mode allows the air vehicle to fly itself based on flight instructions stored on-board. These flight instructions are programmed prior to launch and may be changed in flight when the data link is operational. Preprogrammed flight control provides for a more survivable and flexible UAV system.

A related problem is the method of navigation specified for the JUAV-CR. The UAV-Close requires the air vehicle be capable of autonomous navigation between selectable waypoints. The waypoints are programmed into the air vehicle prior to launch, or may be changed while in flight. The JUAV-CR calls for navigation operations to be performed manually by the flight operator. Manual navigation functions, as well as flight control will fail if the data link carrying the flight commands from the operator to the air vehicle is lost for any reason.

Autonomous navigation allows the air vehicle to continue the mission along a designated flight route until the data link can be reestablished. Even more important, the air vehicle could be programmed to return to a holding

area or the launch/recovery site if the data link were completely lost or jammed.

The required flight endurance time stated for the UAV-Close is three hours. The JUAV-CR system concept states an endurance ranging from one to six hours. There is no stated requirement for the JUAV-CR to exceed the minimum one hour flight endurance time. While the Army requirements permit the use of multiple air vehicles to achieve the required mission endurance, this assumes the air vehicles are capable of conducting continuous operations over the target area.

Unlike the JUAV-SR, the JUAV-CR does not possess the ability to do so. The air vehicle performing the surveillance must return to the launch site and be recovered before another air vehicle may be sent forward to the target area. This inability to relieve another air vehicle on station will create gaps in the surveillance mission.

Although not appearing to be a major issue, the difference in payload carrying capacity could impact on future missions for the JUAV-CR. While the UAV-Close does not specify a weight limit for payloads, the JUAV-CR states the air vehicle be capable of carrying payloads up to fifty pounds. This does not impose a problem with the imagery collection payloads currently planned for use. However, future mission payloads may well be limited to this weight restriction, thus inhibiting growth of the system.

The JUAV-CR system does not call for a remote video monitor capability. UAV-Close follows the same concept as the UAV-Deep and JUAV-SR, specifying the provision of video monitors able to locate with tactical headquarters needing real-time intelligence from the UAV. The video monitors allow any headquarters to receive real-time imagery when the air vehicle is operating within radio line-of-sight of the video monitor antenna. This allows the tactical commander the ability to literally "see over the hill" as events happen. To accomplish the same task without the remote video monitor capability would entail the assignment or attachment of a JUAV-CR system to every unit requiring close range UAV imagery.

Primary Conclusions

Two primary conclusions have resulted from this study. First, Army requirements for UAV development and operation are clearly defined and found to be valid. Second, and foremost, the joint UAV program will satisfy the requirements of the United States Army for an intelligence collection UAV program. Although the joint program uses a different concept of UAV development and employment, the critical needs of the Army are satisfied. A discussion of these conclusions follows.

Army UAV Requirements. The requirements stated in the required operational capability statements for both the UAV-Close and UAV-Deep systems are well thought, support the war fighting doctrine of the Army, and are clearly defined. The roles and missions of the two systems are clearly delineated and fully support Army AirLand Battle doctrine. These requirements fully support the intelligence collection and reporting procedures practiced by the Army. The Army UAV concept is obviously the result of many years of trial and improvement.

The threat environment of future battlefields is fully considered in the Army requirements. Indeed, it is the potential air defense threat that makes the UAV an appealing collection platform. The perceived rapid change in the USSR/Warsaw Pact threat will not affect UAV requirements. Numerous Third World countries possess the same sophisticated technologies as the USSR/Warsaw Pact.

Joint Program Support of Army Needs. The joint program will meet all critical Army UAV needs. Critical needs are defined as the basic requirements necessary to collect day and night imagery over enemy controlled territory and pass the intelligence in near-real-time to the maneuver unit commander. When judged against this base requirement, the differences in the Army and joint programs will not affect mission performance.

The Army and joint UAV programs are similar in many respects. Indeed, the system specifications for the JUAV-SR are almost identical to those developed by the Army for its UAV-Deep. A major change to the joint program since the first UAV Master Plan was drafted in 1988 is the present requirement for UAV systems to share common data link and ground station components.[1] This supports a critical Army requirement that the close and deep range UAV systems be interoperable.

The major difference identified during this research is the potential shortfall in mission endurance times of the JUAV-CR. Should the JUAV-CR system be procured with the flight endurance time at the low end of the specified one to six hour, Army requirements as the UAV-Close will not be met.

Supporting Conclusions

In addition to the two primary conclusions discussed above, several supporting conclusions are also derived. Although the Army and joint programs are similar in many aspects, there are notable differences. It is these differences that form the basis for the majority of the supporting conclusions.

Lack of specificity. A significant finding of this study is that specifications for the JUAV-CR system are not

nearly as well defined as those for either Army system or the JUAV-SR. However, this is not as disturbing as it first appears. A major tenet of the joint UAV master plan is to achieve as much commonality and interoperability as possible among the four joint UAV categories. The method chosen to accomplish this task is to fully develop the JUAV-SR as the lead system, using the experience gained and hardware developed to establish the baseline for future compatibility by the other systems. As a result the JUAV-SR system is in a very advanced state of development. Many of the requirements and specifications to be stated for the JUAV-CR system will depend on the outcome of the JUAV-SR.

Interoperability. The intent of the UAV Joint Program Office is to standardize UAV systems throughout the armed forces. This will permit commonality and interoperability between the services allowing for more efficient joint operations, streamlined logistics channels, and cheaper procurement. All are valid desires.

Interoperability among systems deployed within the same service must be protected. For example, having a JUAV-SR ground control station used by a deployed Army corps that is interoperable with the ground control station used by the Air Force is standardization at the joint level. However, this will mean very little if the same ground station can not exchange control of air vehicles with a JUAV-CR system operating in the divisions subordinate to the corps. While

joint interoperability is desireable, the desire for Army systems to be operate together is even more critical to the synchronization and success of the tactical battle.

UAV systems are well suited to accurately identify, and then conduct surveillance of, targets located by wide area surveillance assets such as the JSTARS system and SIGINT sensors. The capability to automatically pass imagery to the JSTARS GSM will provide timely UAV identification of suspected high value/high pay-off targets located by JSTARS.

One of the keys to good intelligence support is the rapid transmission of accurate combat information to the fire support center for targeting. A direct link between the UAV ground control station and the field artillery automated fire direction system allows the near instantaneous input of accurate targeting data to the fire support system. The automated exchange of target data eliminates the possibility of human error in transmission and greatly speeds transmission time.

The ability of any UAV system to transmit collected information directly to automated systems makes good sense and is technically feasible. A goal of the joint UAV program should be to foster and support this important capability.

JUAV-Close Range in the UAV-Close role. The system concept for the joint close-range UAV envision a much

simpler UAV than the Army UAV-Close. With this comes a much lower expectation of capabilities. The joint approach is truly a bare bones systems with limited capabilities. An example of this is the joint requirement for man-packed operations. This requirement drives a very austere system. As a result many of the capabilities the Army expected to see are not there.

Although the requirements for the JUAV-CR are not yet fully developed, enough of the operational concept is known to determine the close-range UAV envisioned by the joint program is very different from that of the Army's UAV-Close. The UAV-Close closely resembles the UAV-Deep in its concept of operation and system structure. UAV-Close employs a shorter range air vehicle than UAV-Deep, but retains the same separate ground control station and launcher-recovery section method of employment.

The concept for the JUAV-CR describes a system much lighter than UAV-Close, requiring less equipment and fewer personnel. The entire JUAV-CR system is manned and operated by two personnel. The air vehicle is launched and recovered from a combination ground control station and launch-recovery section. The JUAV-CR will operate from the company and battalion area.

Although an entirely different approach from that taken by the Army, the JUAV-CR will meet the Army's needs. The extra equipment and personnel are not required if the

simpler approach works. This eliminates the need for hand-off of the air vehicle between controllers as only one ground station in involved. The remote video monitors specified for the UAV-Close will not be needed if each battalion possesses its own dedicated UAV team.

The identified shortcomings are shortened mission endurance time, the lack of capability to conduct continuous sustained operations, and a reduced payload weight. The result will be decreased times of surveillance of designated areas and/or activities. The possibility will exist that critical intelligence information was missed due to a gap in collection coverage.

The inability to pre-program the UAV for flight is an example of this reduced capability. The Army desires this capability for ease of training personnel as well as the ability of the air vehicle to continue operations if the data link is effectively jammed or contact is lost. This capability allows the air vehicle to return to a designated area and/or self recover in case the data link carrying the flight control commands is lost.

The limited payload capacity of the JUAV-CR may impede the future growth of the system. This is to be expected of a system offering the advantages of a lightweight and highly mobile UAV. In the long run, the more sophisticated and capable UAV-Close concept may be

capable of providing more complete and coordinated surveillance with the use of fewer airframes.

<u>Endurance Requirements</u>. Neither the JUAV-CR nor the JUAV-SR, as currently specified, meet the Army's desired requirements for mission endurance. This problem is more serious with the JUAV-CR system. While the JUAV-SR system falls short of the Army's desires, the minimal flight endurance requirements are met. But, the shortfall for the JUAV-CR is not so easily remedied.

The small size of the projected JUAV-CR has a very direct impact on the flight endurance to be expected. There just is not as much physical space available for increasing flight endurance as would be possible in a larger air frame. Of course, with the larger air vehicle come other changes to the system. Increasing the size of the air vehicle could very well force the JUAV-CR out of the man-packed category.

The joint program creates an additional UAV category - the endurance UAV (JUAV-E). The role of this system is to conduct much longer duration missions, independent of range to the target area. This system is not suitable to meet the endurance needs of the Army UAV-Close and Deep systems. The introduction of yet another UAV system into the corps and division structure would be asking too much of the already over burdened logistic support structure. The needs of the Army will be best served by introducing the least amount of new and unique equipment into the force structure as

possible. The Army concept of two UAV systems, one at corps and one at division, is much more supportable.

Recommendations

It is recommended the mission duration times of both the JUAV-CR and JUAV-SR be increased to meet the desired requirements of the Army. Specifications for the JUAV-SR prototypes, recently published in a trade magazine, reveal flight endurance times already exceed the minimal Army requirements.[2] This action will result in the Army not requiring the joint endurance category UAV at the tactical level. However, application for the JUAV-E by Army echelons above corps appear very possible and likely.

It is recommended that interoperability among ground control equipment be maintained as a priority requirement. It is critical the JUAV-CR and JUAV-SR systems use common data link and ground control equipment. This will ensure the two systems are capable of being integrated into a complete, flexible collection effort. Interoperability will improve mission flexibility and logistics support. The ability to receive data from other air vehicles will result in increased surveillance with fewer UAV missions.

Recommendations for Further Research

The first recommendation for further research is determining the impact on Army UAV surveillance operations if the JUAV-CR concept as currently written is the final decision of the UAV Joint Program Office. The differences between the currently envisioned UAV-Close and JUAV-CR system concepts have already been discussed. The acceptance of the JUAV-CR as the Army UAV-Close will require changes to the Army UAV program. A close range UAV with less than three hours mission endurance will seriously impact on mission effectiveness.

The relationship between service interoperability within echelons of command, or joint interoperability between services, is recommended for further research. While commonality of equipment among the services may reduce initial acquisition and recurring sustainment costs, it must not take priority over interoperability within a tactical unit. The initial UAV master plan presented this situation. Fortunately, this problem was corrected in later revisions to the master plan.[3]

All attention was directed towards establishing a common family of UAVs for use by all the services. What resulted was commonality among the services within a class of UAV, but the inability of two classes of UAV working within the same corps area to share data links and ground

facilities. Operating a UAV that is interoperable with the Navy and Air Force will mean little to the corps commander that can not integrate his own organic close-range and short-range UAV assets. The increase in mission effectiveness and the resultant saving of American lives will offset any cost disadvantage.

Summary

The requirements for UAV use as intelligence collection platforms by the United States Army are well thought and clearly defined. The Army approach to UAV employment fully supports AirLand Battle and supporting intelligence collection doctrine. It is clear that unmanned aerial vehicles are required to conduct effective intelligence collection missions now and in the future. UAVs will fill the most critical intelligence collection shortfall of the Army today, the lack of real-time imagery intelligence for the tactical commander.

The joint UAV program, as currently structured by the UAV Joint Program Office, satisfies the requirements of the United States Army for tactical intelligence collection UAVs. The joint approach to UAV design is not the same as that of the Army. However, the end result is a family of UAVs meeting the critical requirements of the Army. It is clear the development of the JUAV-SR drew heavily on the

requirements developed for the Army UAV-Deep. The most obvious difference between the two programs is the JUAV-CR category.

The system concept for the JUAV-CR as currently envisioned will make acceptance of this system as the Army UAV-Close difficult. Doing so will force a new look at how the Army plans to employ its close-range UAV system. The result is sure to be a more decentralized approach, assigning UAV teams directly to battalion and brigade headquarters, as opposed to consolidating UAV assets at the divisional Military Intelligence Battalion. Even so, if employed in the proper numbers, and with mission endurance times of three hours or better, the JUAV-CR should provide the tactical commander the real-time intelligence information he needs to conduct effective combat operations.

If forced to, the JUAV-SR can also perform the close range missions originally assigned to the UAV-Close. Although probably not as cost effective, increased numbers of the JUAV-SR system provided with adequate numbers of remote video monitor terminals could offset the lack of a UAV-Close system if required.

The joint UAV program is alive and well. Barring funding cuts, the program is rapidly progressing toward fielding operational UAV systems in the near future. Award of the production contract for the JUAV-SR is near, with production to begin in fiscal year 1992.[4]

Procurement of the currently specified JUAV-SR will provide the Army with a system capable of fulfilling its UAV-Deep intelligence collection mission. UAV-Deep will finally provide the tactical level commander a long needed capability - the ability to receive near-real-time imagery of enemy positions and formations. The collection asset required to conduct meaningful target development deep in the enemy territory will finally be available. The arrival of the UAV will dramatically increase the effectiveness of tactical intelligence collection operations.

CHAPTER SIX

ENDNOTES

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[2]Philip J. Klass, "Pentagon Will Select Two Contractors To Demonstrate Unmanned Aerial Vehicles," Aviation Week and Space Technology, (31 July 1989): 34-35.

[3]UAV Master Plan - 1990 Update, 11-13.

[4]Ibid., 9.

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